THE PLANT DISEASE REPORTER

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your references carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

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ACCEPTANCE OF MANUSCRIPTS

The increase in the volume of pertinent material offered for publication in the Plant Disease Reporter has made it necessary to limit the subject matter and the length of articles accepted. The subject matter should emphasize new things in plant pathology, such as new records of disease occurrence, serious outbreaks and epidemics, conditions affecting development of plant diseases, techniques of investigation including instrumentation, new discoveries in control including new materials and their evaluation. Manuscripts will be limited to 12-double-spaced typed pages, including tables, graphs, and photographs. Because of reproduction costs photographs should be kept to a minimum. Insofar as possible, material should be presented as graphs rather than tables. Papers cannot be accepted for publication that report routine control experiments, reviews, bibliographies without annotation, results of routine surveys, mere summaries or lists of plant diseases. By following this procedure we hope to continue publishing all articles promptly.

Paul R. Miller

Manuscripts for and correspondence about this publication should be sent to:

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IN THIS ISSUE

TREES AND FRUITS (see also under Nematodes, Virus)

CURTIS MAY and JOHN G. PALMER found that of the nine fungicides tested for their antiseptic value when added to an asphalt varnish used as a tree wound paint, phenyl mercury nitrate was the only one that retarded growth in pure culture of all of the 11 decay fungi included in their experiment, page 955.

In an experiment conducted in Georgia over a period of 3 years, JOHN R. COLE successfully eliminated Spanish-moss from the Schley variety of pecan by the annual application to the trees of a dormant spray of copper sulfate and calcium arsenate, page 960.

Since attempts to isolate a causal organism for the shrivel disease of dates were completely negative, PAUL R. HARDING, Jr. thinks that the cause of this disease, which may result in severe losses in California, is other than bacterial or fungal, page 962.

Preliminary results of a study initiated in Arkansas to determine the cause of chlorosis of loblolly and shortleaf pine seedlings indicated a higher than normal content of calcium in soil from chlorotic areas, according to CHARLES L. WILSON, page 964.

PAUL D. KEENER describes a large conk of Fomes pinicola found growing on the trunk of a Douglas fir on the North Rim of the Grand Canyon, page 966.

NEMATODES (see also under Miscellaneous)

R. MANKAU and O. F. CLARK have investigated the types and distribution in citrus soils of the nematode-trapping fungi associated with the citrus nematode in nine southern California counties, page 968.

In California trials comparing the susceptibility of three Citrus spp. to three species of root-knot nematodes, S. D. Van GUNDY, I. J. THOMASON, and R. L. RACKHAM discovered that in the seedling stage the popular rootstock Troyer citrange is subject to invasion by all three nematode species, whereas sour orange is susceptible to only one species and sweet orange apparently to none, page 970.

According to the authors, EUGENE BINDER and MARTIN T. HUTCHINSON, failure in an experiment of root-knot nematodes to break resistance in tomato to Fusarium wilt suggests that breaking ability of the nematodes is related to their pathogenicity, which, in turn, is related both to race of the nematode species and to the number of them used initially for inoculation, page 972.

A. MORGAN GOLDEN reports that tests on the pairing habits of the sugar-beet nematode show that it apparently does not reproduce parthenogenetically, page 979.

JAMES M. EPPS and ALBERT Y. CHAMBERS add mung bean to the list of 13 other plants previously reported as being suitable hosts for the soybean cyst nematode, page 981.

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M. B. LINFORD and HARLAN L. RHOADES demonstrate the efficacy of an ordinary spin washing machine, acting as a centrifuge, for removal of surface water from roots prior to determination of moist weights, page 987.

Results of work by JAMES R. BREECE and W. H. HART suggest that nematodes may be responsible for the transmission of peach yellow bud mosaic virus, page 989.

VIRUS (see also under Nematodes)

ROBERT H. FULTON and DONALD CATION obtained effective control of the rosette mosaic virus disease of peach seedlings by soil drenches with the insecticide chlordane and offer several explanations as to the reason why, page 991.

PAUL R. FRIDLUND's thorough study of the time of tissue contact necessary for transmission of the necrotic ring spot virus of Prunus has revealed that time is inversely related to temperature, page 993.

P. W. MILLER notes the recurrence in Oregon of witches' broom in strawberry plants, after what seemingly is an absence of over 30 years, page 996.

CEREALS AND FORAGE CROPS (see also under Vegetable Crops, Miscellaneous)

C. O. JOHNSTON lists the relative abundance of the various physiologic races of leaf rust

of wheat in the United States in 1958, page 998.

J. G. MOSEMAN and C. W. ROANE discuss the reactions of barley varieties to races of leaf rust and the frequency of isolation of physiologic races in the United States in a 3-year period, page 1000.

JOHN G. MOSEMAN summarizes information pertaining to the discovery of new pathogenic strains of powdery mildew of barley in British Columbia and Ontario, Canada and in northeastern United States, page 1004.

M. D. SIMONS and L. J. MICHEL describe two new races of crown rust of oats and review the races identified in the United States in 1958, page 1010.

The fungus-seed association records for the last 15 years have been tabulated by W. F. CROSIER and E. C. WATERS for the purpose of ascertaining variation in percentage of infection by Fusarium spp. and Epicoccum spp. of barley, oats, rye and wheat seedstocks, page 1013.

HOWARD W. JOHNSON reports results of fungicide treatment tests of several forage legume seeds in terms of stand yields, page 1016.

VEGETABLE CROPS (see also under Nematodes)

ROBERT B. MARLATT gives a description of the effect on disease incidence and yield (as well as indications of phytotoxicity) of the application to field-grown lettuce of six micronutrients in the form of foliar sprays or soil dressings, page 1019.

Significant reduction of root rot resulted when gibberellin was added to the fungicides applied to bean plants as foliar sprays, according to greenhouse screening trials conducted by ROBERT L. RACKHAM and JOHN R. VAUGHN, page 1023.

With the end goal of finding rotation crops that will build up land fertility and at the same time reduce root rot hazard to succeeding crops, CHARLES R. MAIER has studied the effect of the crop residues of 11 New Mexico rotation crops on relative populations of bean root-rot pathogens and on severity of root rot, page 1027.

Pellicularia rolfsii was responsible for a higher than usual loss of watermelons in the Chicago market this year, according to a report by G. B. RAMSEY, M. A. SMITH, L. BERAHA, and W. R. WRIGHT, page 1031.

ORNAMENTALS

KENNETH F. BAKER and O. A. MATKIN cite the unusual occurrence in California of the profuse development of morels in a nursery bed of cymbidiums, representing the first instance known in which morels have appeared abundantly under conditions approaching those of potential commercial production, page 1032.

From a 5-year study on the nature and causes of stunt disease of poinsettia stock plants, C. M. TOMPKINS recommends a method of control that is both effective and inexpensive, page 1034.

C. M. TOMPKINS obtained excellent control of leaf rot of unrooted and rooted poinsettia softwood cuttings by curtailing overhead irrigation, page 1036.

JOHN A. BOOTH and STANLEY M. ALCORN isolated four morphological growth types of Fusarium spp. in inoculation experiments to determine the cause of seedling rot of saguaro cactus, page 1038.

MISCELLANEOUS

Aspergillus niger has generally been considered to be a non-cellulose-decomposing organism of cotton, but MARION E. SIMPSON and PAUL B. MARSH report that decomposition was observed with this fungus when a small amount of glucose was added to the cellulose, page 1042.

CHARLES R. MAIER states that a survey of the major cotton-growing areas of 13 counties in New Mexico revealed that in 1959 cotton seedling disease losses amounted to over 2 percent of the total potential cotton crop, page 1048.

SAMUEL W. BRAVERMAN submits a first report of a Stemphylium species on comfrey at Geneva, New York, page 1050.

New records of diseases of six field crops in Israel are enumerated by G. MINZ and Z. SOLEL, page 1051.

Book Review, by JESSIE I. WOOD, page 1052.

Brief Notes, page 1052: Prediction of oat yellow dwarf epidemic, by JOHN F. SCHAFER, RALPH M. CALDWELL, W. B. CARTWRIGHT, and R. L. GALLUN. Late-frost damage to corn in southern Wisconsin, by PAUL E. HOPPE.

EFFECTS OF ASPHALT VARNISH-FUNGICIDE MIXTURES ON GROWTH IN PURE CULTURE OF SOME FUNGI THAT CAUSE DECAY IN TREES

Curtis May and John G. Palmer[1]

INTRODUCTION

Use of an antiseptic paint to protect exposed wood of shade trees from infection by fungi is commonly recommended. Walter[2] reported that the fungus Ceratocystis fimbriata f. platani, the cause of the fatal canker stain of London planetree, would survive and could be spread from tree to tree in non-antiseptic wound paint, which often becomes contaminated during use. He found that no infection resulted when sawdust with C. fimbriata f. platani growing in it was mixed with asphalt varnish containing 0.02 percent phenyl mercury nitrate, and the paint was applied to wounds on planetrees. But when sawdust with the same fungus growing in it was mixed into non-antiseptic asphalt varnish and the paint was applied to wounds on planetrees, infection resulted. No fungi causing decay of wood in trees were included in Walter's study.

Effects of an asphalt varnish paint containing one or more fungicides on the growth in pure culture of several fungi causing decay of wood of shade trees are reported here.

MATERIALS AND METHODS

Fungi and Fungicides

The fungicides selected for study were: captan, dichlone, ferbam, maneb, phaltan, phenyl mercury nitrate, thiram, zineb, and a nickel carbamate. The fungi used were: Fomes fraxineus, Pholiota adiposa, Pleurotus ostreatus, Polyporus adustus, Polyporus pargamenus, Polyporus sulphureus, Polyporus tulipiferae, Polyporus versicolor, Poria monticola, Schizophyllum commune, and Stereum purpureum[3]. Fungi causing decay of sapwood and of heartwood or of both are represented. Some cause white rots and some brown rots.

Preparation and Use of the Paints

Asphalt paint of the gilsonite varnish type of the class of Federal Specification TT-V-51 was used as the vehicle for all of the fungicides tested. The fungicides were thoroughly mixed into the asphalt varnish. The mixtures were allowed to stand for at least 24 hours before use. Generally two drops of each formulation were placed on the surface and in the approximate center of the nutrient agar in each Petri plate. The amount of paint used each time varied somewhat because of the difficulty of regulating precisely the size of each drop. For the purposes of the tests the variation was not important.

Preparation of Cultures

Approximately 20 ml of hot, commercially prepared potato-dextrose or malt agar were poured into each Petri plate. Transfers of bits of mycelium and agar were usually made to three positions near the margin of the hardened medium and approximately at the apices of the angles of an equilateral triangle. In the test of captan only two fungus colonies were established in the plates. The cultures were incubated at 70° F. In most of the tests the asphalt-fungicide mixture was placed on the agar after the fungi had started to grow. In one test the mixtures were placed on the agar before the fungi were transferred to the plates.

In two tests paints were applied to filter paper. The painted paper was dried in air for 24 hours. The papers were divided into two lots -- one of which was washed continuously for 7 hours in running water. Both sets of papers were cut with a cork borer into round sections 12 mm in diameter. The sections were placed on the agar in the center of each plate and were tested for fungitoxicity by their effect on the growth of the selected fungi.

Each test series consisted of five plates, with a total of 15 fungus colonies except for the

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[1]Plant Pathologists, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland.

[2]Walter, J. M. Canker Stain of Planetrees. 1946. Rev. 1950. U. S. Dept. Agr. Cir. 742.

[3]The authors thank Frances Lombard, Division of Forest Disease Research, U. S. Forest Service, for supplying identified cultures of the fungi.

formulation containing captan, as noted previously. Five plates with no asphalt varnish and five with asphalt varnish without fungicide served as controls in each series. After 7 to 14 days the width of the fungus-free zone between the edge of the paint and the margin of the fungus colony was measured.

RESULTS

The fungi grew vigorously on both malt-and potato-dextrose agar. Generally they covered the entire surface of the agar by the end of the observation period. However, the several species grew at different rates. When asphalt varnish without added fungicide was put on the agar, radial extension of the colonies was not retarded or only slightly retarded. The fungi grew up to or over the non-antiseptic paint in most cultures (Fig. 1).

Captan: The formulation contained 0.5 gm captan and 99.5 gm asphalt varnish. Radial growth of mycelium of Fomes fraxineus, Polyporus sulphureus, Polyporus versicolor (Fig. 2), Poria monticola, Schizophyllum commune, and Stereum purpureum was retarded for a few days, but after 10 days the fungi had grown against or over the paint. Schizophyllum commune produced fruiting bodies in the cultures. Radial growth of mycelium of Pleurotus ostreatus, Polyporus adustus, and Polyporus tulipiferae was not retarded by the paint.

Dichlone: The formulation contained 0.5 gm dichlone and 99.5 gm asphalt varnish. Growth of Pholiota adiposa, Pleurotus ostreatus, and Poria monticola was retarded but growth of the other test species was not greatly affected. The dichlone-asphalt varnish formulation soon became too thick and viscous to use as a paint.

Ferbam: The formulation containing 0.5 gm ferbam mixed into 99.5 gm asphalt varnish markedly retarded but did not prevent radial growth of Pleurotus ostreatus, Pholiota adiposa, Polyporus pargamenus, and Stereum purpureum. Growth of Fomes fraxineus was thin and flat but came within 2 mm of the paint after 10 days. The remaining species grew up to the paint within 10 days. Schizophyllum commune produced sparse, lumpy growth and formed fruiting bodies.

A formulation containing 1.0 gm ferbam mixed into 99.0 gm asphalt varnish retarded Schizophyllum commune, which grew slowly. In 10 days Fomes fraxineus, Polyporus adustus, P. sulphureus, P. versicolor, and Stereum purpureum had grown up to the paint. Other species grew within 2 to 6 mm of the paint in 10 days (Fig. 3).

The formulation containing a mixture of 0.5 gm ferbam and 0.5 gm phaltan mixed with 99.0 gm asphalt varnish and another containing 1.0 gm of each fungicide mixed with 98.0 gm of the varnish (Fig. 4) retarded markedly radial growth of Pholiota adiposa, Polyporus pargamenus, and Schizophyllum commune. Fomes fraxineus and Polyporus adustus had grown up to the paint in 10 days. These mixtures soon became too viscous to use as a paint.

Maneb: Radial growth of mycelium of the fungi was not inhibited by a mixture of 0.5 gm maneb and 99.5 gm asphalt varnish.

Nickel carbamate: Radial growth of mycelium of the fungi was not retarded by a mixture of 0.5 gm of the compound and 99.5 gm of the varnish.

Phaltan: Phaltan was somewhat more effective than captan in retarding growth of the fungi. Radial growth of mycelium of Pholiota adiposa, Polyporus pargamenus, Polyporus sulphureus, Poria monticola, and Schizophyllum commune was markedly retarded. Growth of Polyporus adustus and Polyporus tulipiferae was not retarded. Growth of Fomes fraxineus, Pleurotus ostreatus, and Stereum purpureum was slightly retarded. The formulation containing 0.5 gm phaltan and 99.5 gm asphalt varnish could not be considered sufficiently fungitoxic for use as a wound paint. The formulation containing 1.0 gm phaltan and 99.0 gm asphalt varnish (Fig. 5) retarded growth of Polyporus pargamenus more than the paint containing 1.0 percent of ferbam, but no important differences were observed in the effects of the two formulations on the other species.

Phaltan-ferbam mixtures: These mixtures are discussed under ferbam.

Phenyl mercury nitrate: The formulation contained 0.25 gm phenyl mercury nitrate mixed with 99.75 gm asphalt varnish. It greatly inhibited growth of all the fungi when it was placed on the culture medium after the fungi had started to grow. No visible extension of mycelium of the fungi on the culture medium took place when the asphalt varnish-phenyl mercury nitrate mixture was placed on the hardened agar 3 days before the fungi were transferred to it (Fig. 6).

Thiram: Asphalt varnish containing 0.5 gm thiram mixed with 99.5 gm varnish retarded growth of Pholiota adiposa and Pleurotus ostreatus but was not effective against the other test species. However, both P. adiposa and P. ostreatus grew over the paint within 2 weeks.

Zineb: Radial extension of mycelium of the fungi was not retarded by a mixture of 0.5 gm

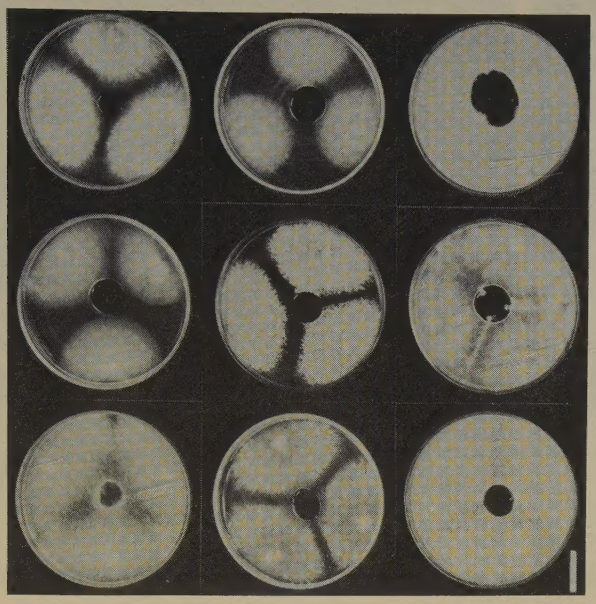
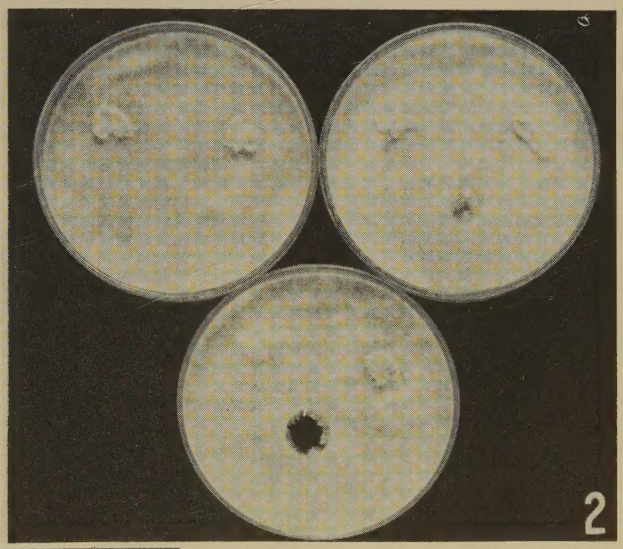


FIGURE 1. Growth on potato-dextrose agar of fungi exposed for 10 days to effects of two drops of asphalt varnish without added fungicide. Fungi are, left to right, top to bottom, by rows:

Top row -- Fomes fraxineus, Pholiota adiposa, Polyporus adustus.
Center row -- Polyporus pargamenus, P. sulphureus, P. versicolor.
Bottom row -- Poria monticola, Schizophyllum commune, Stereum purpureum.



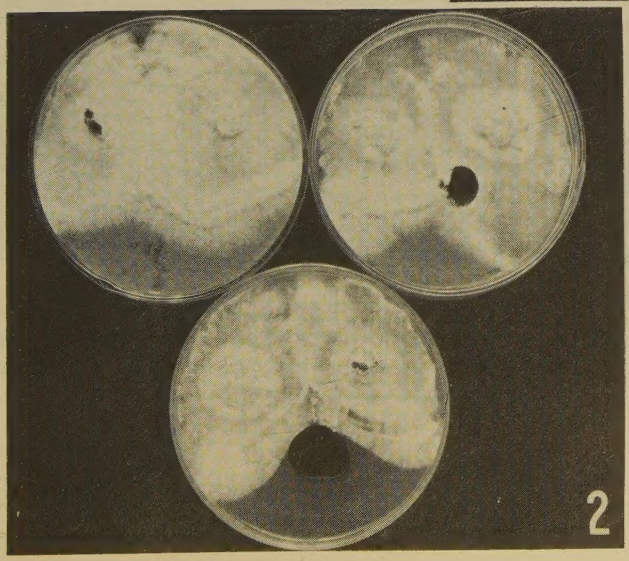


FIGURE 2. Effects of captan in asphalt varnish on growth on malt agar of Polyporus adustus (above) and Polyporus versicolor (left). In each set of plates the upper left has no asphalt varnish added; the upper right has two drops of asphalt varnish without fungicide; and the lower has two drops of a mixture containing 0.5 gm captan and 99.5 gm asphalt varnish. Cultures photographed 7 days after paint was added. P. versicolor grew over the paint in 10 days.

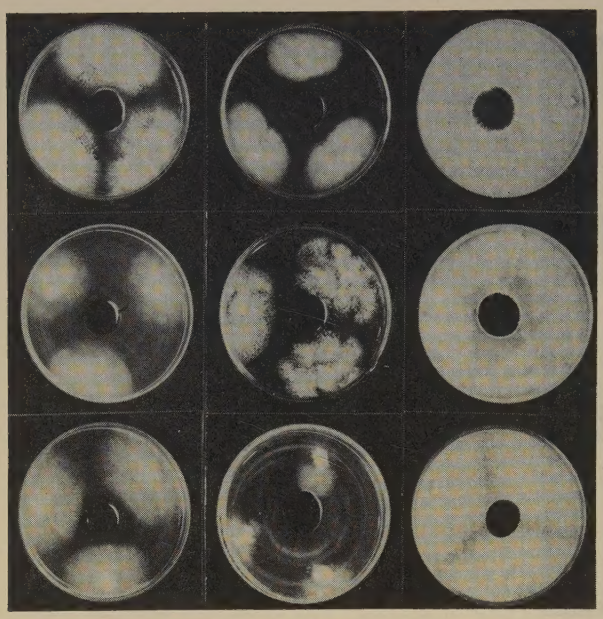


FIGURE 3. Growth on potato-dextrose agar of fungi exposed for 10 days to effects of two drops of a mixture of 1.0 gm ferbam and 99.0 gm asphalt varnish. Cultures arranged as in Figure 1.

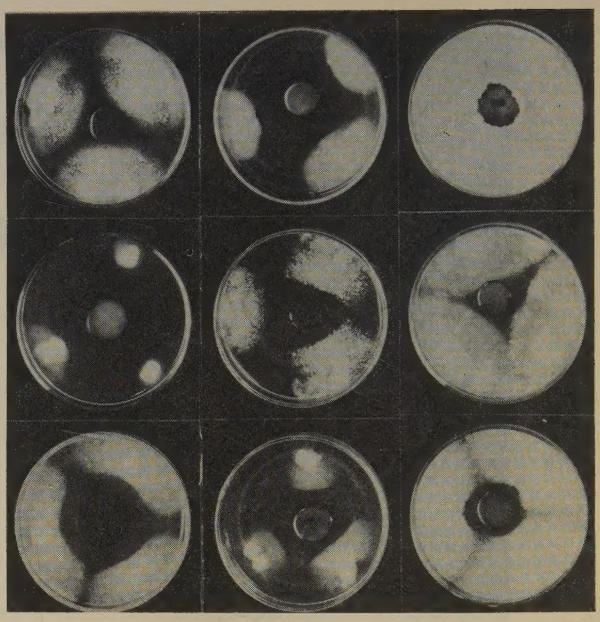


FIGURE 4. Growth on potato-dextrose agar of fungi exposed for 14 days to effects of two drops of a mixture of 1.0 gm ferbam, 1.0 gm phaltan and 98.0 gm asphalt varnish. Cultures arranged as in Figure 1.

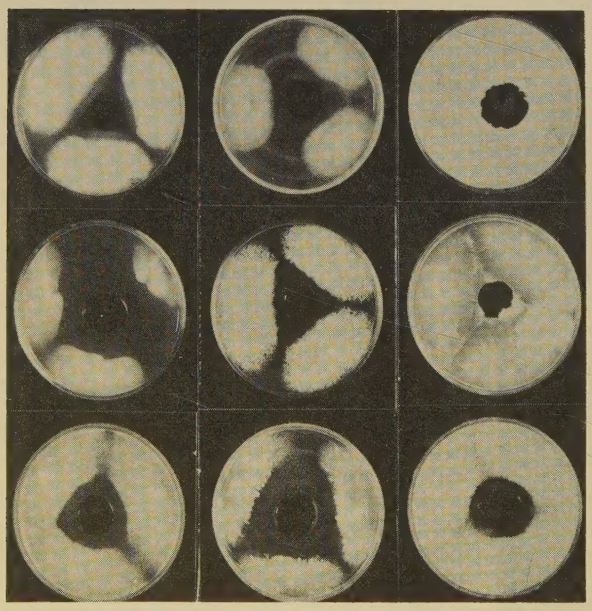


FIGURE 5. Growth on potato-dextrose agar of fungi exposed for 14 days to effects of two drops of a mixture of 1.0 gm phaltan and 99.0 gm asphalt varnish. Cultures arranged as in Figure 1.

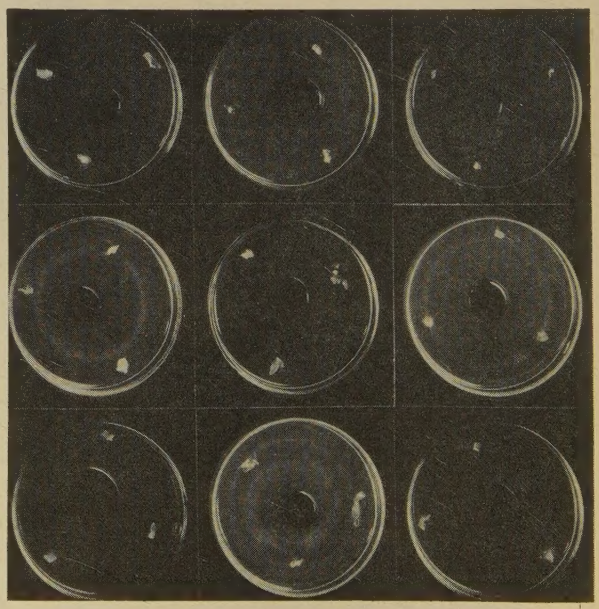


FIGURE 6. Growth on potato-dextrose agar of fungi exposed for 14 days to two drops of a mixture of 99.75 gm asphalt varnish and 0.25 gm phenyl mercury nitrate. Cultures arranged as in Figure 1.

zineb and 99.5 gm asphalt varnish.

Comparison of washed with unwashed dry paints: Nine of the fungi (Fomes fraxineus, Pholiota adiposa, Polyporus adustus, P. pargamenus, P. sulfureus, P. versicolor, Poria monticola, Schizophyllum commune, and Stereum purpureum) were tested against discs prepared as previously described. The paints contained 1) 1.0 gm ferbam, 2) 1.0 gm phaltan, 3) 0.5 gm ferbam plus 0.5 gm phaltan (each mixed with 99.0 gm asphalt varnish), 4) 1.0 gm ferbam plus 1.0 gm phaltan mixed with 98.0 gm varnish, 5) 0.25 gm phenyl mercury nitrate mixed with 99.75 gm varnish, and 6) the asphalt varnish alone. For the ferbam-phaltan mixtures, which retarded growth of some of the fungi, and the phenyl mercury nitrate, which retarded growth of all of the fungi, there were no marked differences in the growth of the fungi 1) to the painted, unwashed discs, 2) to the painted, washed discs, and 3) to the fresh paint.

Both 1.0 gm ferbam and 1.0 gm phaltan mixed separately with 99.0 gm asphalt varnish retarded growth of Fomes fraxineus when drops of the viscous mixtures were assayed, but neither did when the painted discs were assayed. Neither the freshly-prepared nor painted and dried ferbam-phaltan mixtures retarded F. fraxineus. Unlike the liquid mixture, the painted and dried 1.0 gm ferbam mixture failed to retard the growth of Stereum purpureum. The responses of the fungi to these mixtures were not different after the dried paints had been leached with running water for 7 hours.

DISCUSSION

The formulation containing 0.25 gm of phenyl mercury nitrate in 99.75 gm asphalt varnish was the most effective in inhibiting growth of the test fungi. None of the other formulations retarded growth of all of the fungi.

Ferbam retarded the growth of two fungi that phaltan did not (Pleurotus ostreatus and Stereum purpureum); phaltan noticeably retarded the growth of three fungi that ferbam did not (Polyporus sulphureus, Poria monticola, Schizophyllum commune); both compounds retarded the growth of Pholiota adiposa and Polyporus pargamenus. The differences in fungitoxicities suggested that a mixture of ferbam and phaltan in the varnish might retard growth of a greater number of fungi than either alone. Unfortunately this effect was not secured. Moreover, asphalt varnish to which both were added soon became too stiff to use, but if used before stiffening the activity of the fungicides in retarding fungus growth was not impaired.

Relative solubility and rate of migration of the active ingredients in water or in the nutrient agars probably influenced the width of the fungus-free zone. Most of the compounds used are relatively insoluble in water. A compound that migrates rapidly in nutrient agar should result in a wider fungus-free zone during a standard period of elapsed time than a compound of equal fungitoxicity that spreads slowly in it.

A tree wound paint should protect from infection wood that it covers, but it need not be fungitoxic at a distance from its point of application. Indeed, action at a distance would imply diminution of the concentration of the fungicide in the paint and, if the loss were rapid, could impair its effectiveness. However, spread of the fungicide into underlying wood should provide additional protection against penetration by fungi causing decay. Extensive tests on wounds on trees would be required to determine the effectiveness of an antiseptic paint in protecting them from decay.

An asphalt varnish paint containing 0.25 percent of phenyl mercury nitrate should be sufficiently antiseptic to prevent spread of many species of wood decay fungi through the use of contaminated paint and probably would prevent infection by fungi carried to pruning cuts on contaminated tools. These benefits could be secured even though the antiseptic was volatile or soluble in water and was dissipated after a few days or weeks.

The effect of the asphalt varnish-fungicide mixtures on the growth in culture of some of the fungi is shown in Figures 1 through 6.

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SPANISH-MOSS IN PECAN TREES CAN BE CONTROLLED BY SPRAYING DORMANT TREES WITH COPPER SULFATE AND CALCIUM ARSENATE

John R. Cole[1]

The common gray moss, or Spanish-moss, (Tillandsia usneoides L.), is rapidly becoming a pest to pecan growers in the coastal areas, especially where pecans are growing near live oak trees. The moss is not parasitic since it derives its food from the air, rain, and dew. It grows on both trees and some inanimate objects. It is usually most troublesome in neglected orchards in areas having poor air movement and high humidity. Large accumulations of Spanish-moss are detrimental to tree vigor and growth because of the shading effect.

Spanish-moss needs sunlight for best growth; therefore trees should be kept vigorous so that they will provide maximum shade. One method of eliminating this moss is by inaugurating an improved cultural and fertility program including annual applications of fertilizers, together with winter cover crops as recommended for good culture.

FIGURE 1. Tree infested with Spanish-moss.

Since some growers are interested in rejuvenating old pecan orchards, in 1956 the writer began a dormant spray program on trees moderately infested with Spanish-moss (Fig. 1). The trees are typical of hundreds growing in south Georgia and north Florida. The experiment, located 4 miles south of Albany, Georgia, consisted of single-tree plots of the Schley variety replicated nine times. Annual spray applications of 10 pounds of copper sulfate and 10 pounds of calcium arsenate in 100 gallons of water were made on February 8, 1956; February 19, 1957; and March 28, 1958. The trees had not been fertilized or cover-cropped for at least 10 years. The only care they had received was an annual mowing for control of weeds.

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FIGURE 2. Tree growing adjacent to tree in Figure 1 after three annual spray applications of 10-10-100 copper sulfate-calcium arsenate mixture. The moss has been almost entirely eliminated from this tree. At the beginning of the test both trees showed about the same amount of infestation.

At the end of three years the moss was eliminated, for all practical purposes (Fig. 2). The dead moss hung in the trees for some time but eventually blew out.

The writer has also observed orchards where the moss has been eliminated from pecan trees after a Bordeaux mixture spray program for the control of scab and other diseases had been in progress for several years. However, it was necessary to use more than three applications of the spray material at summer strength (6-2-100) to control the pest effectively.

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THE PREHARVEST SHRIVEL DISEASE OF DATES

Paul R. Harding, Jr.[1]

Summary

Of the several species of fungi isolated from inflorescence strands bearing shriveled dates, none was found capable of infecting healthy inflorescence strands either in Petri dishes of agar or on the trees. Since no bacteria have been found definitely associated with the disease, it seems likely that the disease is not of fungal or bacterial nature.

INTRODUCTION

A disease of dates referred to by date growers as "green shrivel" (Fig. 1) causes severe losses to the date industry of Indio, California. Although the disease has been believed to be one of a physiological nature, the exact cause has not been determined. In an early stage of ripening, affected dates become shriveled and hard. The disease is associated with death of

FIGURE 1. "Green shrivel" disease of dates.

the inflorescence strands in toto or in part. In the Coachella Valley about 15 percent of the dates are affected in a normal year, and in a bad year about 25 percent; in the worst years the amount of shrivel may be as high as 50 percent. Shriveled dates are down-graded and have to be disposed of at lower prices. Some of the "shrivels" are softened in the packing houses by treatment with steam and then marketed as low quality dates, but a large percentage is too hard to be salvaged in this manner, and must be chopped or ground for use as livestock feed or in special types of products.

MATERIALS AND METHODS

Sections of inflorescence strands bearing shriveled dates were surface-sterilized by immersion for 1 or 2 minutes in 2.5 percent sodium hypochlorite solution or 50 percent ethanol, rinsed thoroughly in sterile water, and than placed in Petri dishes of nutrient agar. The ability of fungi emerging from these strands to infect healthy inflorescence strands was tested by two

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different methods. One method involved placing live sections of healthy inflorescence strands near colonies of the fungi in Petri dishes of nutrient agar. Another method involved inoculating inflorescence strands in the trees. The inoculum for this work was prepared by growing the fungi on pipe cleaners coated with nutrient agar in Petri dishes of nutrient agar. Inoculation was performed by wrapping a short section of a fungus-bearing pipe-cleaner around each inflorescence strand. These inoculations were made in three series: one shortly after emergence from the spathe; another, 1 month after pollination; and another, 3 1/2 months after pollination. In the Petri dishes of nutrient agar and on the trees, inoculation experiments were performed with and without injury to the inflorescence strands. Injury was accomplished by making a shallow notch about 0.5 mm deep in the side of the strand.

RESULTS AND CONCLUSIONS

Several species of fungi emerged from the strands. Alternaria tenuis auct., Aspergillus phoenicis (Corda) Thom[2], a species of Fusidium, and two species of Chaetomium were of most frequent occurrence. No fungus infections of healthy inflorescence strands were obtained either in Petri dishes of nutrient agar or on the trees. Since no bacteria were found definitely associated with the disease, and since the shriveled dates themselves generally were free of fungi, it seems probable that the shrivel disease is not caused by bacteria or by the fungi used in these tests. The writer realizes that some disease organisms are difficult to establish in living tissues artificially, and wishes to make allowance for a possibility that certain vectors, climatic conditions, or techniques of inoculation might enable one or more of the above fungi to establish a parasitic relationship.

Fawcett and Klotz (2) found Ceratostomella paradoxa (d. Seyn.) Dade, Diplodia phoenicum (Sacc.) Fawcett and Klotz, and a species of Fusarium, to be causal fungi in certain types of inflorescence decay in Arizona and California. Mauginiella scaettae Cavara is the principal fungus responsible for inflorescence decay in Cyrene, Tunisia, Algeria, Morocco, and Italy (1) and in Iraq (3). The writer did not find any of these fungi associated with the shrivel disease of dates. Moreover, the symptomatology of shrivel disease is unlike that of any of these organisms. C. paradoxa causes "black scorch" disease of the inflorescences in unopened spathes. D. phoenicum causes a similar disease. In infections with M. scaetae ("khamedj" disease), the inflorescences in unopened spathes are turned brown and become covered with white powdery masses of spores. In infections with Fusarium, the symptoms are similar but without the white powdery spore masses. In all four cases the young floral parts are affected in unopened spathes prior to formation of fruit. By contrast, shrivel disease occurs at a much later period of development in which the fruits are affected in an early stage of ripening near the time of transition from green to pink.

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[2] The writer believes A. phoenicis and A. niger van Tieghem belong to the same species. The two have been considered separable on the basis that in the former the primary phialides are about twice as long, 40-60 microns, as in the latter (4). Since isolates with intergrading sizes of primary phialides were frequently obtained, and since the size of these structures is the only means of separating the two species, it is likely that only one species is involved which should be referred to with the older name A. phoenicis.

CHLOROSIS OF LOBLOLLY AND SHORTLEAF PINE SEEDLINGS RELATED TO CALCIUM CONTENT OF NURSERY SOIL[1]

Charles L. Wilson

For several years there has been an unexplained chlorosis of short-leaf (Pinus echinata) and loblolly pine (Pinus taeda) seedlings in the Arkansas State Forestry Commission nursery at Bluff City, Arkansas. A study was initiated in 1958 to determine the cause of this condition. Since the study area has now been taken out of production and continued work on this problem is not anticipated, these preliminary results are presented at this time.

The symptoms of this disease are similar on loblolly and shortleaf pine, and they appear first around the middle of July. Symptoms develop as an overall yellowing of the needles. Chlorotic seedlings may die, or they may recover their normal coloration. No lesions on the stem or roots were found associated with the chlorosis. Mortality of roots and mycorrhizae occurs on severely affected seedlings. Areas involving as much as 100 square feet of nursery bed may be affected. These areas did not appear to be associated with abnormal soil moisture or any other peculiar condition within the bed and were randomly distributed within the nursery. It was thought, at first, that this disease might be caused by nematodes, but counts made from soil in the chlorotic and green areas did not reveal a relationship between parasitic nematode populations and the chlorosis[2].

MATERIALS AND METHODS

Soil analyses were made by the Arkansas Agricultural Experiment Station Soils Testing and Research Laboratory. Calcium was determined by the normal ammonium acetate extraction method and phosphorus was determined colorimetrically[3]. Soil at the Bluff City nursery is a loamy fine sand. Soil samples were collected with a soil tube injected about 4 inches. Two samples were taken in each case, one from a chlorotic area and one from an adjacent normal area 6 to 24 inches away. No distinction was made between the two species of pine in the study.

RESULTS

In general, the chlorotic areas had a higher pH and a greater amount of available K_2O and Ca (Table 1), but the only consistent difference in all determinations was in the calcium content. In all determinations the calcium content in the chlorotic areas was considerably higher than that in the normal green areas (Table 2). The pH of soil from chlorotic and adjacent normal areas was determined in the field with a portable pH meter on September 16, 1958 (Table 3), and no significant differences in pH were found. However, there is some indication that the pH of the soil during certain periods of the growing season may be related to the chlorotic condition. When the pH was determined August 1, it was consistently higher in the chlorotic areas than in the normal green areas.

Since a higher pH, or at least higher calcium content, was characteristic of the chlorotic areas, it was thought that a deficiency of Fe or Mg might exist. September 7, 1958, a chelated iron compound, Fe Tracin (9 grams/gallon of water), and $MgSO_4$ (9 grams/gallon of water) were applied as foliar sprays to eight plots, each 48 square-feet in area, that were chlorotic. No response was observed from the application of these materials. These results are inconclusive.

When the nursery beds are made up, the soil is mixed well with a rototiller. It is surprising that there would be as much variation in calcium content as there was in adjacent areas in the same bed. No explanation could be found for this localized accumulation of calcium in the soil.

This information is presented for consideration in diagnosing chlorosis in pine nurseries. It would be possible to confuse the symptoms of this condition with nematode damage.

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[1] Approved by the Director of the Arkansas Agricultural Experiment Station. This study was made possible through the cooperation of Paul M. Adams and the Arkansas State Forestry Commission.

[2] Appreciation is expressed to Dr. R. D. Riggs who made the nematode analyses.

[3] Beacher, R. L. 1956. Methods for rapid soil testing. Soil Testing Laboratories, University of Arkansas. (Mimeographed).

Table 1. Average soil analysis values from chlorotic and green areas.

Date sampled	Plant condition	Percent organic matter	Available P_2O_5	Available K_2O	Available Ca	pH
			(pounds per acre)			
August 1	chlorotic	1.7	400	240	1420	6.1
	green	1.5	400	190	840	5.5
September 16	chlorotic	1.1	400	250	1500	5.3
	green	1.1	400	180	900	5.7

Table 2. Calcium content of soil in chlorotic and green areas.

Plant condition	Plot 1	2	3	4	5	6	7	8	9	10	11	12
	(pounds per acre)											
Chlorotic	1200	1500	1500	1800	1100	1600	1500	1300	1300	1200	2300	1200
Green	700	1100	800	1000	600	900	900	900	1200	800	1000	900
Chlorotic (average)	1460											
Green (average)	900											

Table 3. pH of chlorotic and normal green areas, taken in the field, September 16, 1958.

Plant condition	Plot 1	2	3	4	5	6	7	8	average
Chlorotic	5.8	5.4	4.9	4.6	5.4	5.0	5.2	5.2	5.2
Green	5.2	5.2	5.0	5.2	5.0	5.0	6.6	6.0	5.4

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SPOROPHORE SIZE IN FOMES PINICOLA (SWARTZ EX FRIES) COOKE[1]

Paul D. Keener

Arid regions are generally regarded as inferior situations for the development of sporophores (conks) of many wood-rotting fungi. In Arizona, numerous isolated mountains rise from the desert valley floors so that in reality regions of high elevations result which normally receive more rainfall than the deserts. In addition, winter snowpacks may -- but do not always -- occur in the higher altitudes, thus adding to the soil moisture. Nevertheless, it is commonly accepted that in the arid Southwest much of the snow sublimates into the atmosphere and considerable moisture is lost as far as soil replenishment and vegetation benefits are concerned.

Fomes pinicola (Swartz ex Fries) Cooke is one of the most commonly encountered fungi attacking conifers in Arizona.

In 1955, while studies on the fungus flora of the area were being pursued, a large conk of F. pinicola was observed on a trunk of Pseudotsuga menziesii (Mirb.) Franco, at Robbers' Roost Canyon, North Rim of the Grand Canyon, Grand Canyon National Park, Coconino County. When removed (fresh) on August 27, the sporophore measured 16 x 9 and 15/16 inches (Fig. 1). After the sporophore dried out at room temperatures for varying periods, the measurements were as given in Table 1.

Table 1. Measurements of a single sporophore of F. pinicola on various dates, after removal from trunk of Pseudotsuga menziesii.

Conditions	Dates	Measurements in inches (centimeters)	
		Length	Width
Original fresh sporophore	8-27-55	16 (40.6)	9 and 15/16 (25.0)
After drying	9-7-55	14.5 (36.8)	9 (22.9)
do.	11-21-55	14 (35.6)	8.75 (22.0)
do.	12-31-55	14 (35.6)	8.5 (21.6)

In 1958, approximately 3 years later (August 29), the tree was revisited. Another sporophore had developed on the same bark surface. This conk measured (fresh) 12 x 5.5 inches (Fig. 2). The original sporophore has since been deposited in the Herbarium, Natural Science Study Collections, Visitor Center Building, South Rim, Grand Canyon National Park, Coconino County, Arizona (Specimen No. 4182).

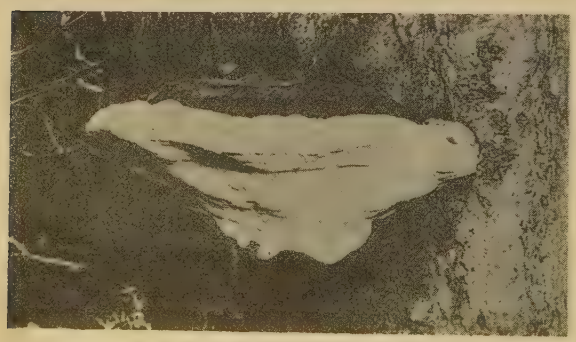

FIGURE 1. Sporophore of Fomes pinicola on trunk of Pseudotsuga menziesii. Robbers' Roost Canyon, North Rim of the Grand Canyon, Grand Canyon National Park, Coconino County, Arizona. August 27, 1955. (Grand Canyon Herbarium No. 4182).

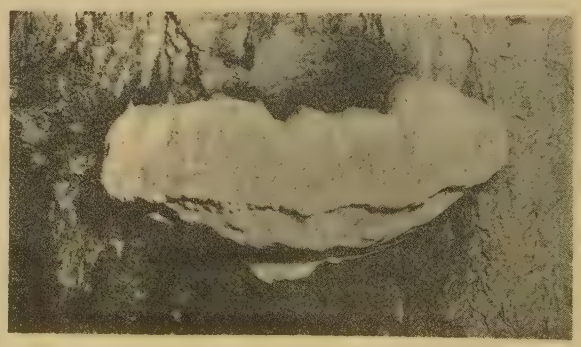

FIGURE 2. Sporophore of Fomes pinicola on the same tree and same bark surface as the specimen shown in Figure 1. August 29, 1958.

[1] Arizona Agricultural Experiment Station Technical Paper No. 534.

Numerous sporophores of F. pinicola have been observed throughout the conifer forests of the State. It is rather certain that this species, along with Polyporus anceps Peck (the cause of Western Red Rot), are the most common on Western Yellow Pine (Pinus ponderosa Laws.) in Arizona. On the other hand, Fomes officinalis (Vill. ex Fries) Faull., (= Laricifomes officinalis (Vill. ex Fries) Kotl. & Pouzar (3)) (Fig. 3), is rather uncommon at Grand Canyon and elsewhere. This is in keeping with data on some herbarium labels and specimens collected as early as 1918 and at other times (F. P. #30669) by previous investigators, ma-

FIGURE 3. Sporophore of Fomes officinalis from trunk of Pinus ponderosa. South of Highway 64, West of Grand View Point, East Rim Drive, South Rim of the Grand Canyon, Grand Canyon National Park, Coconino County, Arizona. October 18, 1956.

terials of which are on deposit in the Herbarium, United States Department of Agriculture, Forest Service, Forest Insect and Disease Laboratory, Albuquerque, New Mexico. However, Overholts (2) asserts that Hedgcock considered F. officinalis common on P. ponderosa in Northern Arizona. Present studies do not verify this opinion.

It is interesting to note that of the recent writings on the Polyporaceae, only Overholts (2) gives measurements (4-30 x 6-40 x 2.5-22 cms) for F. pinicola that approximate those reported herein for the 1955 Grand Canyon specimen. The dimensions given in Lowe (1) are generally smaller (15 x 20 x 10 cms) than those for many of the conks produced on Arizona conifer trees.

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NEMATODE-TRAPPING FUNGI IN SOUTHERN CALIFORNIA CITRUS SOILS

R. Mankau and O. F. Clark[1]

As a preliminary phase of an investigation on the role of nematode-trapping fungi in the soil and their effect upon plant parasitic nematode populations, an attempt was made to determine the types and distribution of predacious hyphomycetes associated with the citrus nematode, Tylenchulus semipenetrans. Over 50 samples were taken from various southern California citrus groves and examined for the presence of these fungi.

MATERIALS AND METHODS

Soil samples were examined by placing small pinches of soil (totalling approximately 1-1.5 cc) and root fragments on solidified 1/4 strength Difco corn meal agar in Petri dishes and incubating at room temperatures ranging from 22° to 30° C. The root fragments were pressed into the agar. The use of a weak corn meal agar permits the growth of bacteria upon which some nematodes feed and increase their numbers yet does not encourage the growth of many saprophytic soil fungi requiring richer media. This medium also supplies sufficient nutrient for the saprophytic growth of predacious hyphomycetes in the absence of nematodes. The use of plain water agar would suffice for the examination of California citrus soils since citrus nematode larvae can be readily obtained in large numbers from most citrus root fragments. The former technique is, however, preferred for general soil examination.

The Petri dishes containing the soil and root fragments were observed for a period of from 1 to 2 months before discarding. Most nematode-trapping hyphomycetes appear within 2 weeks after plating.

RESULTS

Fungi isolated from the soil samples are listed in Table 1 with the number of times they occurred in different samples. Arthrobotrys dactyloides, A. arthrobotryoides and Dactylella

Table 1. Nematode-trapping fungi isolated from citrus soils in nine California counties.

Fungus species	No. of records	Fresno	Los Angeles	Orange	Riverside	San Bernardino	San Diego	Santa Barbara	Tulare	Ventura
Arthrobotrys spp.	7				+					
A. arthrobotryoides (Berl) Lindau	21	+	+	+	+	+	+	+	+	+
A. conoides Drechs.	9	+	+		+	+				
A. dactyloides Drechs.	23		+	+	+	+	+	+	+	+
A. oligospora Fres.	2				+		+			
Dactylella ellipsospora Grove	3				+			+	+	
D. gephyropaga Drechs.	14		+	+	+	+	+	+	+	+
Dactylella spp.	7				+			+		+
Dactylaria brochopaga Drechs.	3		+		+					
Dactylaria candida (Nees) Sacc.	3				+					
Total	92									

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gephyropaga were the species most often encountered in citrus groves (23, 21 and 14 records, respectively). Most of the isolates listed as Arthrobotrys sp. are undescribed species, as are some of those listed as Dactylella sp. A few of these species have been listed (1) as occurring in mulch treatments applied to citrus orchards.

It is interesting to note that Arthrobotrys oligospora, which Drechsler (2) mentioned as the most ubiquitous predacious form in his extensive collections and which was also reported as the most common fungus isolated from agricultural soils in England by Duddington (3), is of rather infrequent occurrence in citrus soils examined by us.

No particular preponderance of species with certain types of trapping mechanisms could be noted. A. dactyloides traps nematodes in constricting hyphal loops, as does Dactylaria brochopaga and D. candida. A. oligospora, A. arthrobotryoides, A. conoides and D. gephyropaga utilize sticky hyphal meshes while D. ellipsospora possesses sticky knobs to which the nematodes adhere.

Table 1 also lists which species occurred in various southern California counties and indicates a rather widespread distribution of most species. The fact that all of the species encountered were recorded from Riverside County is a reflection of more intensive sampling in this region. Two undescribed Arthrobotrys spp. were obtained from soil samples in Butte County in the north-central region of the State which were not encountered in southern California.

While examining the plated samples, other fungi attacking nematodes were often encountered which were mostly phycomycetes. This group was observed to be parasitic mainly on saprozoic free-living forms, with the exception of Catanaria anguillulae which was occasionally found in stylet-bearing nematodes. These fungi included the following: Cephalosporium sp., Catanaria anguillulae Sorokin, Haptoglossa heterospora Drechsler, Harposporium anguillulae Lohde, Stylopage hadra Drechsler, Nematoctonus leiosporus Drechsler, and N. tylosporus Drechsler.

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THE REACTION OF THREE CITRUS SPP. TO THREE MELOIDOGYNE SPP.

S. D. Van Gundy, I. J. Thomason and R. L. Rackham[1]

Abstract

Two populations of Meloidogyne javanica and M. incognita acrita and one population of M. hapla produced galls on Troyer citrange roots. Both populations of M. incognita acrita produced galls on sour orange roots. None of the three Meloidogyne spp. produced galls on sweet orange roots. No egg masses or adult females were observed in material examined after 8 weeks. Numerous swollen second-stage larvae were found in the galls.

Root-knot nematode galls were first reported on citrus by Neal (5) in 1889. Most reports of root-knot nematode on citrus appearing in host range lists (1, 2, 3, 5) do not mention the observation of reproduction or description of species and, in general, citrus is considered resistant to the root-knot nematodes. Minz (4) has recently reported finding females of Meloidogyne javanica (Treub) Chitwood on Citrus aurantifolia Swingle var. dulcis.

This investigation was initiated when approximately 20,000 Troyer citrange (Citrus sinensis x Poncirus trifoliata) (L.) Raf. seedlings were found badly galled by M. javanica in a nursery. The source of inoculum was from roots of a nearby tamarisk hedge (Tamarix gallica L.). The roots of tamarisk (that were running throughout the seedbed) were badly infected with M. javanica, and with each irrigation apparently produced a flush of larvae which entered the succulent citrus roots. A similar bed of sour orange (Citrus aurantium L.) seedlings did not show any galling. No egg masses or mature females were found in examinations of the roots. Numerous swollen second-stage larvae were found in the galls. Most of the larvae were vacuolate, granular and many appeared dead.

To check for further development of the nematodes, 12 of the galled plants were planted in sterile soil and held for 4 months in the greenhouse. No reproduction or new gall formation was observed.

Since Troyer citrange is a popular citrus rootstock in California, further evidence was needed concerning its susceptibility to root knot. Two populations each of Meloidogyne javanica, M. incognita acrita Chitwood, and M. hapla Chitwood were inoculated to Troyer citrange, sour orange and sweet orange (Citrus sinensis Osbeck). Two plants of each variety were inoculated with 100 gm of galled tomato roots and 250 cc of infested soil. This was repeated for each population. All of the populations were started originally from a single egg mass and maintained on tomato roots. The seedlings were harvested 2 months after inoculation. Results are summarized in Table 1.

Table 1. The reaction of three Citrus spp. to three Meloidogyne spp.

Species	Population number	Troyer citrange	Sour orange	Sweet orange
M. javanica	1	10-20 cylindrical galls	-	-
	2	20-30 cylindrical galls	-	-
M. incognita acrita	1	10-20 small galls	5-10 small galls	-
	2	5-10 small galls	5-10 small galls	-
M. hapla	1	5-10 "hapla galls"	-	-
	2	-	-	-
Check		-	-	-

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FIGURE 1. Galls on Troyer citrange seedling produced by Meloidogyne javanica.

Both populations of M. javanica and M. incognita acrita and one population of M. hapla produced galls on Troyer citrange. Both populations of M. incognita acrita produced galls on sour orange. There was no galling of sweet orange by any of the three species of root knot tested. No egg masses were found on any of the galls. Dissected galls were found to contain numerous swollen second-stage larvae. No third-stage larvae were found.

The galls on Troyer citrange produced by M. javanica were very similar to those found in the field, long and cylindrical (Fig. 1). The galls produced by M. incognita acrita were similar to those produced by M. javanica, except smaller. "Hapla galls" were very similar to those produced on other crops by M. hapla, being very small, with numerous branching of the feeder roots.

It appears that root-knot larvae are capable of entering and galling citrus roots, although there is only partial development of the nematode. The results of these tests indicate that if the trees were planted in the field no further development of the nematodes and galling of the roots would take place. The three citrus species tested differed in susceptibility to different root-knot nematode species.

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FURTHER STUDIES CONCERNING THE EFFECT OF THE ROOT-KNOT NEMATODE MELOIDOGYNE INCOGNITA ACRITA ON THE SUSCEPTIBILITY OF THE CHESAPEAKE TOMATO TO FUSARIUM WILT

Eugene Binder and Martin T. Hutchinson[1]

Abstract

A population of Meloidogyne incognita acrita, relatively non-pathogenic to field grown cantaloupe, was used in an experiment designed to duplicate the results of Jenkins and Coursen (13) in breaking the Fusarium wilt resistance of the Chesapeake variety of tomato. Although the tomato roots were heavily galled, resistance to Fusarium wilt was not impaired, either under conditions of normal nutrition, or of a nutrition deficient in potassium. Moreover, a highly significant increase in root growth of plants normal in nutrition was produced by infection with nematodes. These results, in marked contrast to those obtained by Jenkins and Coursen, suggest that ability of root-knot nematodes to break resistance in tomato to Fusarium wilt is closely related to their pathogenicity; also, that pathogenicity is related both to the race of the nematode species used and to the number of nematodes initially inoculated.

INTRODUCTION

The development of immune tomato varieties of good commercial quality was thought to be the ultimate solution of the Fusarium wilt problem (1). However, reports concerning the ability of root-knot nematodes to increase susceptibility of tomato varieties to Fusarium wilt have since appeared in the literature.

Young (23) reported that root-knot nematodes increased susceptibility to Fusarium wilt in both susceptible and tolerant tomato varieties under field conditions in Texas. Harrison and Young (10), working in the field with what must have been Meloidogyne incognita, M. incognita acrita, or M. javanica, confirmed the work of Young, and found "a distinct correlation between the number of root galls and the severity of tomato wilt." However, the nematodes did not affect resistance of the immune variety Bohn-Tucker 643. In contrast, McClellan and Christie (16) found that near-maximum galling by an unidentified species of Meloidogyne had no effect on the susceptibility of the tolerant Marglobe tomato to Fusarium wilt in the greenhouse. Jenkins and Coursen (13), working in the greenhouse with a population of M. incognita acrita that was markedly pathogenic to Chesapeake variety of tomato in the field, were able to break completely the resistance of this variety to Fusarium wilt. Previously, the Chesapeake tomato, a variety containing the same genetic resistance as Bohn-Tucker 643 (19), had been considered immune to Fusarium wilt. Jenkins and Coursen used a large initial number of nematodes and noted that "severe stunting resulted from inoculations with root-knot nematodes alone."

The possibility that nutrition of the plants, and particularly potassium nutrition, might be related to the contradictory results of the experiments cited above was indicated by other workers.

Oteifa (18), using a pathogenic race of M. incognita, showed that the nematodes caused a highly significant decrease in the potassium content of lima beans grown at normal levels of nutrition, and also demonstrated that "damage caused by the nematodes may be reduced by increasing the level of potassium supplied to the plant." Walker and Foster (22) had previously reported that potassium deficiency increases the susceptibility of tomato to Fusarium wilt.

In an attempt to link infection by root-knot nematodes (M. incognita acrita) and level of potassium nutrition with effect on the Fusarium resistance of Chesapeake tomato, a greenhouse experiment was conducted during the summer of 1958.

MATERIALS AND METHODS

Nematode inoculum was obtained from very heavily galled roots of cantaloupe, var.

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Harvest Queen, grown in a sandy field near Allentown, New Jersey. According to the grower[2], the plants were not too badly stunted, and although they lost their leaves at the end of the growing season they produced a very good crop -- better than some nearby fields that were not infested with root-knot (5). Identification of M. incognita acrita was confirmed by A. L. Taylor (21). Large numbers of females and larvae were present in the galls. The inoculum was prepared by cutting the roots into small pieces and triturating them in a Waring Blendor with a small quantity of water just before inoculation onto the tomato plants.

Tomato seed of the Queens and Chesapeake varieties was obtained from F. H. Woodruff and Sons, Milford, Connecticut. The seedlings were started in perlite and were given an optimum supply of nutrients until they had about four leaves, at which time they were transplanted to 6-inch plastic pots containing washed quartz sand. They were watered with either a complete nutrient solution, or with one lacking in potassium (Table 1). The complete nutrient solution attempted to approximate the complete fertilizer with trace elements used by Jenkins and Coursen (Jenkins, 12).

Table 1. Composition of the complete nutrient solution used for growing the tomato plants[a].

Macronutrients (salts)	Molar concentration
$Ca(NO_3)_2 . 4H_2O$	.0045
$MgSO_4 . 7H_2O$	.002
KH_2PO_4	.00025
$NH_4H_2PO_4$	.00075
K_2SO_4	.002

Micronutrients (salts)	Parts per million
$FeSO_4$	.9 Fe
H_3BO_3	.1 B
$MnSO_4 . H_2O$	.25 Mn
$CuSO_4 . 5H_2O$	.01 Cu
$Na_2MoO_4 . 2H_2O$	.01 Mo
$ZnSO_4 . 7H_2O$	.1 Zn

[a]In the potassium deficient nutrient solution, K_2SO_4 was omitted.

The temperature in the greenhouse fluctuated between 95° F during the day and 70° at night. Relative humidity fluctuated between 30 percent during the day and 75 percent at night.

One month after transplanting, a portion of the nematode-root suspension (containing about 1000 eggs and larvae) was injected deep into the pots, using a Cornwall syringe. The pots were placed on a bare, tiled bench to minimize transfer of nematodes.

The strain of Fusarium oxysporum f. lycopersici was obtained from Dr. C. M. Haenseler, who had collected it from a tomato field near Matawan, New Jersey. The procedure used in the preparation of Fusarium inoculum was the same as that of Jenkins and Coursen (13). Fusarium was cultured in a medium containing 10 gm Bacto peptone, 20 gm sucrose, 0.25 gm magnesium sulfate, 0.5 gm monopotassium phosphate, and 1000 ml water. After 1 week, the floating fungus mats were removed. Using a Waring Blendor, two aqueous suspensions were made, one of which was more concentrated than the other. Six weeks after the tomato seedlings were transplanted, and 2 weeks after nematode inoculation, 20-ml aliquots of the dilute suspension were injected into the pots and .1-ml aliquots of the concentrated suspension were injected into the bases of the plant stems. Plants not receiving Fusarium had their stems injected with an equal amount of water.

As noted in Table 2, ten different treatments were used, with five replicates each. The pots were randomized by use of a table of random numbers.

[2]The collection was made by the grower, Mr. George Fuelner, and was submitted by the County Agricultural Agent, Mr. M. A. Clark, in August 1958.

Table 2. Treatments used to determine the effect of Meloidogyne incognita acrita on the susceptibility of the Chesapeake tomato to Fusarium wilt[a]

Treatment	Tomato variety	Potassium nutrition	Meloidogyne	Fusarium
1	Queens	normal	-	-
2	Queens	normal	-	+
3	Chesapeake	normal	-	-
4	Chesapeake	normal	-	+
5	Chesapeake	deficient	-	-
6	Chesapeake	deficient	-	+
7	Chesapeake	normal	+	-
8	Chesapeake	normal	+	+
9	Chesapeake	deficient	+	-
10	Chesapeake	deficient	+	+

[a]Each treatment was replicated five times.

The experiment was conducted for 7 weeks following the inoculation with Fusarium, after which all inoculated plants were evaluated and examined for latent infection with Fusarium and for the number of nematodes present in the roots.

RESULTS

None of the Chesapeake tomatoes showed external or internal symptoms of Fusarium wilt, regardless of whether they were inoculated with root-knot nematodes, or were or were not grown under conditions of potassium deficiency. However, severe symptoms of wilt were present on all Queens tomatoes inoculated with the Fusarium fungus only.

Since the fungus had no apparent effect on the inoculated Chesapeake tomatoes, data taken from these plants were combined with data from uninoculated plants receiving the same treatment. Now there were considered to be four different treatments of Chesapeake tomatoes, with 10 replicates of each. These data, summarized in Table 3, show that M. incognita acrita caused a highly significant stimulation in growth of roots normal in nutrition; representative root systems are shown in Figure 1. Near-maximum galling was obtained with some

Table 3. Summary of effects of M. incognita acrita on growth of Chesapeake tomato[a].

Treatment	Average weight in grams: Total plant	Roots	Fruit
Normal K			
No nematodes[b]	301	40	41
M. incognita acrita[c]	334	63	70
Significance of difference	n.s.	1%	n.s.
Deficient K			
No nematodes[b]	132	18	17
M. incognita acrita[c]	149	23	4.5
Significance of difference	n.s.	n.s.	n.s.

[a]Plants became pot-bound soon after inoculation with nematodes.
[b]10 replicates.
[c]8 replicates (two plants died early in the experiment).

of the plants inoculated with nematodes (Fig. 2) These contained up to 375,000 larvae in their roots at time of harvest. However, there was no apparent correlation between the number of larvae found in the roots and the weight of the individual root systems.

FIGURE 1. Stimulation of root growth of Chesapeake variety of tomato by Meloidogyne incognita acrita (right) as compared with uninoculated roots (left).

In the roots normal in nutrition, an average of 2300 (range 500 to 5500) larvae per gram was recovered. In the roots deficient in potassium, an average of 1150 (range 70 to 3950) larvae per gram was recovered. This difference was not significant.

With plants deficient in potassium, the root systems of plants inoculated with M. incognita acrita were as well developed as were those of uninoculated plants. Typical symptoms of potassium deficiency were present on the foliage of plants grown with the nutrient solution lacking potassium.

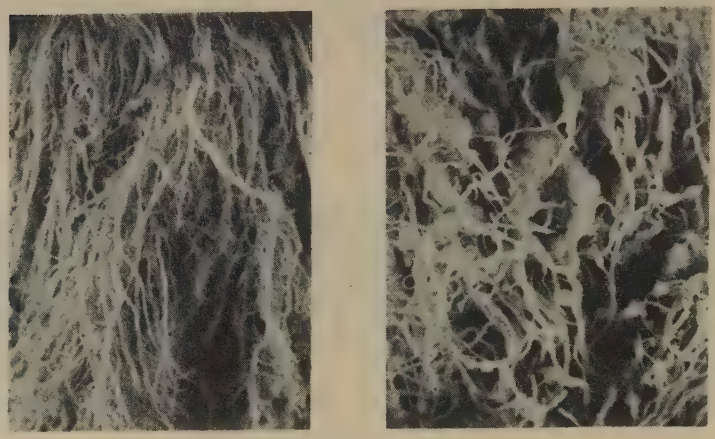

FIGURE 2. Severe galling of Chesapeake tomato roots (right) caused by inoculation with Meloidogyne incognita acrita, compared with uninoculated roots (left).

DISCUSSION

Although the environmental factors of temperature, moisture, photoperiod, and nutrition in the experiment herein described were similar to those used in experiments conducted by Jenkins and Coursen (12, 13), there are three possible sources that could explain the difference in results obtained[3]. These sources are: 1) the race of M. incognita acrita used, 2) number of nematodes initially inoculated, and 3) seedlot of the Chesapeake var. tomato.

Races of M. incognita acrita

The existence of different races of M. incognita acrita has already been well established. These races show differences in morphology, parasitism and, possibly, pathogenicity.

Dropkin (7) noted variability in the morphology of mixed and single-line populations of M. incognita acrita. Later, Dropkin (8) noted that a California population could be distinguished from a Maryland population by the relative production of egg masses on two soybean varieties. Martin (14), using six isolates of M. incognita acrita from a total of five different hosts, showed that three would develop on Deltapine 15 var. cotton, and that three would not. Two of the isolates parasitic on cotton showed marked differences in ability to reproduce galls on a total of seven cotton varieties. Hollis (11) showed similar differences among isolates of an M. incognita - M. incognita acrita complex from several cotton fields in Louisiana. These isolates produced galling in cotton and Rutgers tomato ranging from very slight to very severe. The isolate that was the most severe to cotton was the least severe to tomato. Based on the different amount of galling produced by these isolates, Hollis suggested the existence of pathogenic races of M. incognita and M. incognita acrita. However, no data concerning nematode populations or secondary symptoms (such as stunting) were presented. He also noted that these isolates differed significantly in the average breakdown of Fusarium wilt resistance they caused on several cotton varieties, including the resistant Coker 100 Wilt. This latter result was similar to that obtained by Martin, Newsom and Jones (15), who had observed that two isolates of M. incognita and one isolate of M. incognita acrita differed in ability to increase incidence of

[3]There are certain other procedural differences between the conditions of this experiment and those of Jenkins and Coursen (13). In their experiments, bottom heat was supplied to the inoculated plants, plants were root-dipped for Fusarium inoculum, and Fusarium inoculation took place at the same time as Meloidogyne inoculation. The plants used by Jenkins and Coursen (13) were younger when inoculated than were the plants in the present experiment. Also, the plants of Jenkins and Coursen were grown in soil and were given only approximate amounts and concentrations of a soluble fertilizer. Thus, there could have been rather larger differences between the amounts of nutrients supplied to their plants and amounts supplied to the plants in the present experiment that received the complete nutrient solution. However, the present authors believe that these procedural differences did not substantially affect results.

Fusarium wilt in Coker 100 Wilt.

There are several indications that the population of M. incognita acrita used in the present experiment was a relatively non-pathogenic one. Under field conditions, cantaloupe plants were not seriously affected during a dry growing season, although their roots were very heavily galled at harvest. In the greenhouse, near-maximum galling and large numbers of root-knot larvae at harvest, far from stunting tomato plants, produced a marked stimulatory effect on the root systems of plants normal in nutrition. The nematodes did not cause stunted root growth of plants deficient in potassium.

Number of Nematodes Initially Inoculated

The inoculum used by Jenkins and Coursen was estimated (12) to be about 50,000 eggs and larvae per pot, in contrast with the 1000 egg and larvae used by the present investigators. Therefore the possibility exists that the massive inoculation used by the former workers was the critical factor in breaking resistance to Fusarium as well as in stunting the plants. This possibility is strengthened by results of a preliminary experiment conducted by the present authors during the winter of 1957-1958. Using nematode inoculum from the same source, and probably identical with that of Jenkins and Coursen (Jenkins, 12), no breaking of resistance of Chesapeake variety of tomato was obtained, although conditions satisfactory for the development of Fusarium were maintained, as indicated by infection of all plants of the susceptible Queens variety, using Fusarium alone. In this case, very low numbers of M. incognita acrita were maintained in the pots of soil throughout the experiment. Eight weeks after simultaneous inoculation of the nematodes and the fungus, an average of only 284 larvae were recovered per gram of root. At this population level, total growth of plants inoculated with M. incognita acrita was significantly greater (1 percent level) than that of uninoculated plants. This result indicates that a given race of M. incognita acrita may be stimulatory at low levels and pathogenic at high levels of population.

Other instances of growth stimulation caused by root-knot nematodes have been noted by Chitwood (2), and Chitwood et al. (4) with Meloidogyne hapla on tomato and lima bean, and by M. incognita on peach; by Tarjan (20), using a combination of M. hapla, M. incognita, M. incognita acrita, M. javanica, and M. arenaria on snapdragon; and by Myuge (17), who reported that lima bean roots grown in a water extract from galls of M. incognita made better growth than roots grown in healthy root extract or in water. Chitwood (3) stated, "Farmers and people in soil fumigation work have long known that poor control of root knot gives better crops than good control."

Seedlot of the Chesapeake Tomato

The sources of seed used by the present writers may have differed from that of Jenkins and Coursen (13), who obtained theirs from the University of Maryland's Department of Horticulture (12). Crittenden (6) has noted differences among seedlots of the same soybean variety in regard to ability to support populations of M. incognita acrita. Since neither soybeans nor tomatoes are clonally propagated, some variation among seedlots, and even between individual seeds in the same seedlot, is to be expected and remains as a possible source of difference.

Several experiments are therefore suggested by the findings in this paper. Using the same seedlot of Chesapeake tomato, the inoculation of different numbers of a single race of M. incognita acrita could be studied for effect on stunting the plants and breaking resistance to Fusarium. Two or more races of M. incognita acrita could be compared in this regard. The effect of a luxury level of potassium nutrition on breakdown of resistance to Fusarium by a pathogenic race of M. incognita acrita should be investigated. Since Gothoskar et al. (9) have been able to break the resistance of tomato plants to Fusarium by treatment with respiratory inhibitors, it may be hypothesized that one or more chemical factors is involved in the ability of root-knot nematodes to lower or break resistance, and that root-knot populations unable to lower or break resistance either lack these factors or possess them only to a slight degree. Whenever biochemical methods for working with nematodes are developed, this hypothesis would be an interesting one to test.

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SIGNIFICANCE OF MALES IN REPRODUCTION OF THE SUGAR-BEET NEMATODE (HETERODERA SCHACHTII)

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Summary

No reproduction of the sugar-beet nematode was observed after inoculation of 64 individual sugar-beet seedlings with a single larva each. Two cysts recovered from these plants contained only a few non-viable eggs and 1 cyst had no eggs. Cysts containing viable eggs and larvae were abundant on 16 plants inoculated under the same conditions with 500 larvae each. These results indicate that the sugar-beet nematode apparently does not reproduce parthenogenetically.

Pairing or mating of the sexes in the sugar-beet nematode (Heterodera schachtii Schmidt) was first recorded over 30 years ago, according to Ellenby (1). It is also known that males are generally found easily whenever the females of this species develop to normal maturity, on a host plant. Furthermore, mature males have been found on several different kinds of plants on which no females were observed to reach maturity (3, 4, 8, 9). Whether females of H. schachtii can develop to normal maturity and reproduce without males, however, apparently has not been established.

In determining the chromosome number in the sugar-beet nematode, Mulvey (6) noted that a few of many oocytes examined did not contain sperms; but when sperms were present, only one occurred in each oocyte. Ellenby (1) and Fassuliotis (2) reported that H. rostochiensis Wollenweber does not develop normally or produce viable eggs in the absence of males. Mulvey (7), however, found that H. trifolii reproduced in the absence of males, and Tyler (11) established that a root-knot nematode (Meloidogyne sp.) also could reproduce normally without males.

The present work was initiated to determine whether the sugar-beet nematode could reproduce when males were not present.

MATERIALS AND METHODS

Eighty transparent plastic containers made for carrying pieces of pie in lunch boxes were converted into small observation boxes. These were filled with sterilized soil. A young sugar beet germinated in sterilized sand was transplanted to each of the boxes which were then placed in specially built wooden containers, each holding 16 boxes. The wooden containers were constructed so that the observation boxes, containing the soil and plant roots, were in a dark aerated space while the tops of the sugar-beet plants were exposed to the light. Ten days after the sugar beets were transplanted, a single, freshly-hatched H. schachtii larva (emergence age of 24 hours or less) was placed on a small rootlet of each of 64 sugar beets in the sterilized soil and the site of inoculation was marked on the removable top of the observation box. The remaining 16 boxes were inoculated with 500 larvae each. All plants were grown in the greenhouse at a temperature of 72° to about 85° F for 100 days after inoculation. Every week for the first 7 weeks each observation box was removed and placed under a stereoscopic microscope for examination of the inoculated root and surrounding areas for nematodes. Upon termination of the test, the soil and roots of each plant were washed and sieved to recover nematode cysts.

RESULTS AND DISCUSSION

A few white females and cysts could be seen on the roots of the control plants (inoculated with 500 larvae per plant) by the end of 7 weeks and females and cysts were numerous when the test was terminated 100 days after inoculation. On the roots of the 64 plants inoculated with a single larva each, no nematodes were observed during the 7-week observation period. However, when the soil and roots were washed and sieved after the 100-day period of growth follow-

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ing inoculation, one cyst was found on each of three plants. These three cysts were obviously fresh, but one had no eggs within while the other two contained about 10 eggs each. These two egg-containing cysts were kept for several weeks in root diffusate of sugar beet but not a single larva emerged. Then, microscopic examination of these eggs showed no evidence of cleavage or further development.

The results indicate that males, and presumably fertilization of the females, are necessary in the reproduction of the sugar-beet nematode. If this should be true for this nematode wherever it occurs, the possibility of the existence of biologic races within this species would seem to be less than if the nematode reproduced parthenogenetically. As emphasized by Toxopeus (10), the ability to reproduce parthenogenetically would tend to favor the establishment of new biologic races, or "biotypes," of nematodes. On the other hand, as demonstrated in H. rostochiensis (1, 2, 5), failure to reproduce without males does not necessarily eliminate or prevent biologic races within a nematode species.

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MUNG BEAN (PHASEOLUS AUREUS), A HOST OF THE SOYBEAN CYST NEMATODE (HETERODERA GLYCINES)

James M. Epps and Albert Y. Chambers[1]

Summary

Mung bean (Phaseolus aureus) is reported to be a suitable host for the soybean cyst nematode (Heterodera glycines). Two varieties, Oklahoma 12 and Kiloga, were very susceptible, while a jumbo strain was free of white females when grown under conditions favorable for nematode development.

According to Ichinohe (2, 3) soybean (Glycine max), the wild soybean (G. ussuriensis), and the adsuki bean (Phaseolus angularis), are suitable hosts for the soybean cyst nematode (Heterodera glycines Ichinohe, 1952). Skotland, Sasser, and Winstead (5) reported three additional hosts, annual lespedeza (Lespedeza stipulacea) common vetch (Vicia sativa), and snap bean (Phaseolus vulgaris).

In 1957 Skotland (4) described the results of his test with 45 plant species representing 28 genera and 9 families. He reported Glycine gracilis, Vicia villosa, Lespedeza striata, and L. cuneata as new hosts of the soybean cyst nematode.

Epps and Chambers (1) added three hosts in 1958. These included hemp sesbania (Sesbania macrocarpa), white lupine (Lupinus albus), and henbit deadnettle (Lamium amplexicaule). Henbit deadnettle was the first host reported outside the Leguminosae family.

The present report adds mung bean (Phaseolus aureus) as another host on which the soybean nematode can reproduce.

At the suggestion of Dr. Ralph S. Matlock, Professor of Agronomy, Oklahoma State University, the authors set up tests to determine whether the mung bean could serve as a host for the soybean cyst nematode. Dr. Matlock supplied seed of two varieties, Oklahoma 12 and Kiloga, and of the jumbo type for tests.

The seed were planted in 7-inch clay pots containing soil known to be heavily infested with cysts and larvae of the soybean cyst nematode. After 6 weeks, the plants were lifted from the pots, and the roots were washed and examined under a stereoscopic microscope for white females. Three plantings were made for each of the three kinds at 6-week intervals. Each planting consisted of four pots of each.

Examination of the roots showed heavy populations of white females on the roots of Oklahoma 12 and Kiloga. No white females were found on the roots of the jumbo type in any test. Oklahoma 12 was severely stunted in all tests. While there was a heavy population of white females on the roots of the Kiloga variety, the plants did not show severe stunting.

Since these two varieties and the jumbo type were grown under favorable conditions for nematode development, it appears that the lot of jumbo seed tested possess very high resistance to white female development.

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COOPERATIVE INVESTIGATIONS OF CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND TENNESSEE AGRICULTURAL EXPERIMENT STATION

THE PATHOLOGIC HISTOLOGY OF BEAN ROOTS INJURED BY STING NEMATODES[1]

Marie S. Standifer[2]

Abstract

Bean roots injured by Belonolaimus longicaudatus show damage similar to, but more severe than, that previously described in citrus roots. A lesion consists of a cavity surrounded by affected cells characterized by ruptured cell walls, coagulated protoplasm and altered staining reactions. Injury can be traced vertically and horizontally from the feeding area in most of the root tissues. Lesions occurring at or near apices cause maturation of the meristem.

The sting nematodes Belonolaimus gracilis Steiner, 1949 and B. longicaudatus Rau, 1958 are recognized parasites of herbaceous plants (2, 7, 9). Christie (1) reported that sting nematodes fed at root tips and along the sides of roots and caused necrosis and devitalization of the tips. A histological study of citrus roots injured by B. longicaudatus showed that feeding resulted in lesions and produced additional damage in tissues surrounding the lesions (8). The present study was undertaken to investigate further the pathologic histology of sting nematode lesions.

MATERIALS AND METHODS

Specimens of B. longicaudatus were isolated by established procedures (2) from citrus-grove soil collected near Orlando, Florida. Specimens hand-picked into distilled water were used to inoculate the roots of wax bean seedlings at the time they were transplanted into pots of sterilized soil. Inoculated and uninoculated bean plants were grown under similar conditions in the greenhouse.

Samples of branch roots taken from inoculated and uninoculated bean plants were fixed in FAA, dehydrated according to a tertiary butyl alcohol schedule (6) and embedded in tissuemat. Longitudinal and cross sections were cut at 8μ, stained with a modified Conant's quadruple stain (8) and mounted in Harleco Synthetic Media. With the schedule used, lignified or suberized portions of cells were stained red by safranin. Protoplasm and non-lignified cell walls were blue-green. The observations reported herein are based on serial sections of 10 normal and 10 sting nematode-injured bean roots.

OBSERVATIONS

Control Roots

The histology of uninoculated wax bean roots is similar to that described by Doutt (4) and Harris et al. (5). The roots are characterized by an open type of meristem in which the tissues are derived from a common zone (Fig. 1)

Sting Nematode-injured Roots

The feeding of sting nematodes on bean roots resulted in injury similar to that described on citrus roots (8). Feeding areas were located at root apices (Figs. 2, b; 4; 5, c) and along the margins of roots (Figs. 2, a; 5, a), especially about the bases of branch roots (Fig. 5, b). (The former will be referred to as apical lesions and the latter as lateral lesions.) On one root, lateral lesions occurred at the base of every branch root while parenchyma cells between the branch roots were undisturbed.

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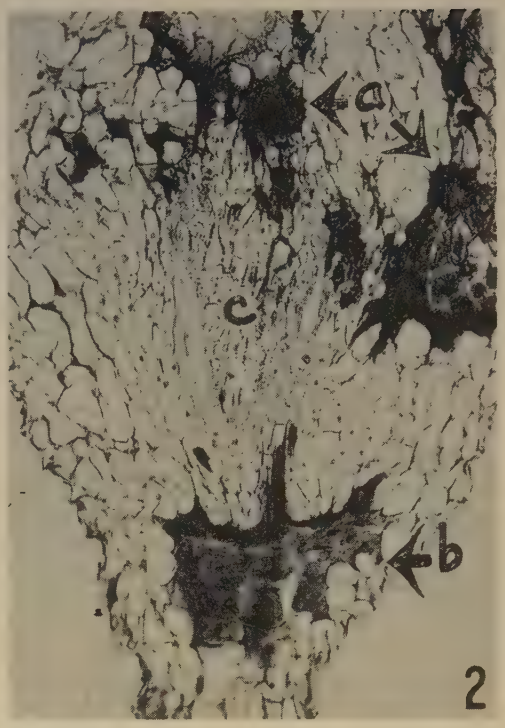

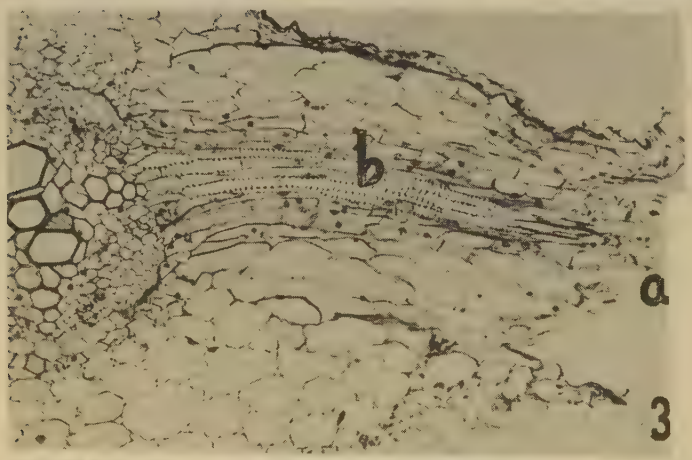

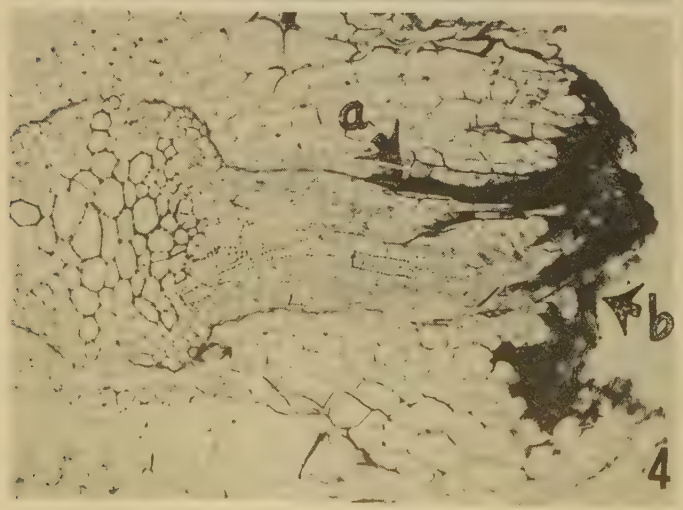

FIGURE 1. Longitudinal section through apex of a control bean root. All tissues arise from a common zone (arrow).

FIGURE 2. Longitudinal section through apex of a bean root injured by sting nematodes. Note densely stained protoplasm of cells in lateral lesions (a), position of apical lesion (b), and mature xylem elements (c) close to the apex.

FIGURE 3. Cross section of control bean root with a branch root seen in longitudinal view. Branch root has been broken at (a) in slide preparation. Contrast appearance of xylem element (b) with Figure 5, e.

FIGURE 4. Cross section of bean root with sting nematode lesion at the apex of a branch root. Note damage in pericycle and endodermis (a) and densely stained, coagulated protoplasm of cells (b).

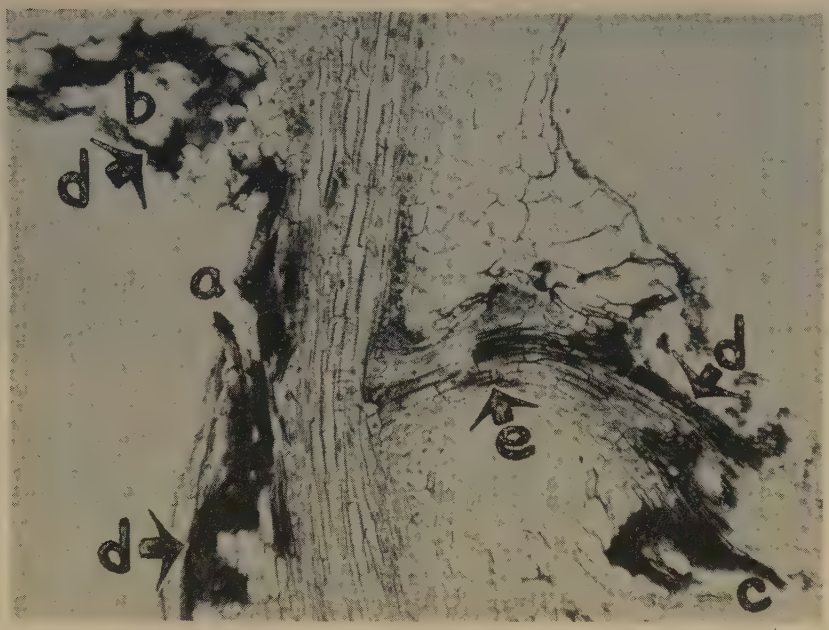

FIGURE 5. Longitudinal section of bean root showing several sting nematode lesions. Feeding has occurred along the root margin (a), at the base of a branch root (b), and at the apex of a branch root (c). Note densely stained, coagulated protoplasm of cells (d) and damage in the xylem (e).

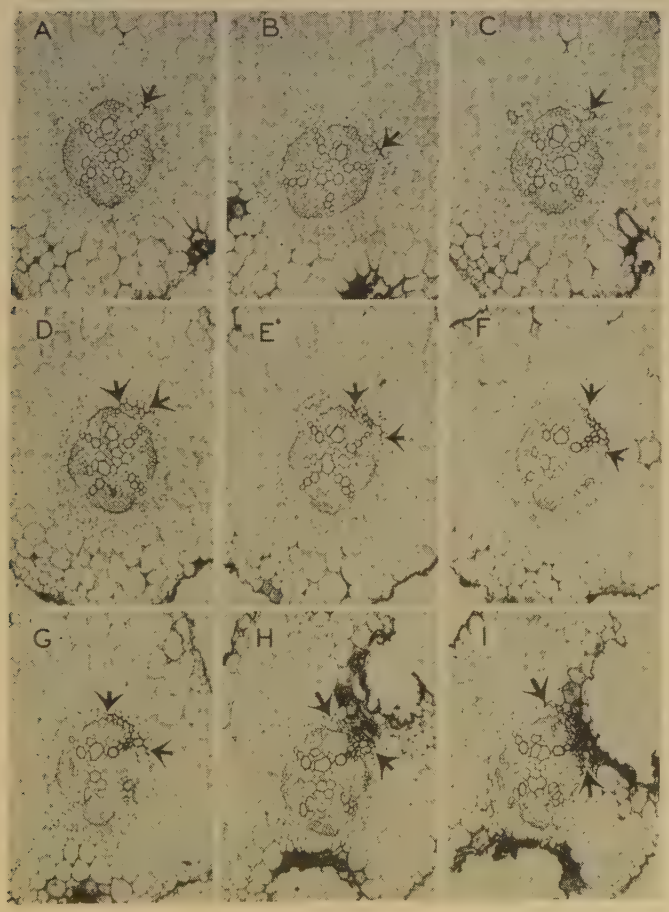

FIGURE 6. Composite plate of cross sections showing extent of sting nematode injury to bean root tissues above a lesion. Starting at A, sections taken approximately every 80μ trace damage (arrows) in the endodermis and pericycle down to a median section of the lesion at I. Smaller lesions are seen in A, B, and C. Heavily stained walls are present in the xylem and cortical cells beginning in F.

The lesions in bean roots generally were large and comprised portions of several root tissues. Lesions frequently extended into the stele and included cells of the xylem (Figs. 3, b; 5, e) and phloem as well as those of the pericycle, endodermis and cortex (Fig. 6, I).

Microscopically the lesions consisted of two distinct parts: a hollow cavity and an area of injured cells which encircled the cavity (Figs. 5, 6). Cavities in bean roots were large proportionately and accounted for the large size of the lesions. Lesion cells were characterized by their deeply red-stained walls and coagulated, red-stained protoplasm (Figs. 2, a; 4, b; 5, d). The walls of cells bordering the cavity had been ruptured.

Effects on contiguous cells were indicated by altered staining reactions. The walls of cells which bordered lesions were lightly stained with safranin, and the intercellular spaces of the cortex contained a material which also stained red (Fig. 6, H and I). Horizontally this injury was evident a few cells away from the lesion, but vertically it was traceable for considerable distances (Fig. 6). The effect extended from one lesion for the following distances:

	μ above	μ below		μ above	μ below
Cortex	1024	880	Phloem	120	136
Pericycle	608	1280	Xylem	320	1328

The maturity of stelar tissues near lesions apparently was affected. When feeding areas were located at or near root apices, a general maturation of the entire root tip occurred (Fig. 2, c). A more mature stele in the vicinity of lateral lesions was suggested by the presence of a true cambium and increased amounts of vascular tissue; these were not present above or below the lesion area.

DISCUSSION AND CONCLUSIONS

The pathologic histology of sting nematode lesions on bean roots appears to be very similar to that described on citrus roots. Correlations occur in the location of lesions on the root, the staining reaction and appearance of the lesions, the evidence of injury above and below lesions and the maturation of tissues near lesions. The deep lesions in bean roots, probably due to the more succulent nature of that plant, include more tissues and result in more damage than was reported in citrus roots.

Damage to cells vertically and horizontally distant from lesions gives additional evidence that the movement of some sort of chemical stimulus is connected with the feeding of the sting nematode. The exact nature of this stimulus could not be determined from this study, but it is believed that mechanical injury alone could not cause reactions so far from lesions. The damage can probably be attributed to a plant response to or the direct effect of a stimulus produced by the nematode. Presumably this stimulus is the salivary secretion.

It can be concluded that injury produced by the feeding of sting nematodes on bean roots is similar to, but more severe than, injury produced on citrus roots. Damage to tissues is more extensive than could be accounted for by mechanical injury alone, and the movement of a stimulus is strongly suggested.

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CENTRIFUGATION OF ROOTS BEFORE DETERMINING MOIST WEIGHT

M. B. Linford and Harlan L. Rhoades[1]

Abstract

The spinning tub of a domestic automatic washing machine is an effective low-speed centrifuge for removal of surface water from washed root systems before determining moist weight. When spinning time and speed are standardized, reproducible results are obtained without allowing any rootlets to dry and shrivel, leaving the root systems in good condition for examination or for extraction of nematodes.

When taking data from pot culture experiments, such as pathogenicity tests of nematodes or fungi, often it is desirable to obtain weights of both tops and roots. For the tops, oven-dry weights usually are preferred. Roots sometimes cannot be washed sufficiently free from adhering sand and silt for dry weights to be as valid a basis of comparison as moist weights, provided that a sufficiently standardized means of removing surface water can be used before weighing. Furthermore, the investigator sometimes does not wish to dry the roots because of a desire to examine them in detail, to extract nematodes from them, or to preserve some of them as specimens. The commonly employed method of preparing roots for fresh weight determination, however, involving draining, shaking, and blotting, leaves much to be desired because compact masses of roots remain too wet even after exposed rootlets have begun to shrivel.

Closely reproducible moist weights are readily obtained without shrivelling of rootlets by folding the washed roots into a compact mass, wrapping in muslin and spinning in the tub of an automatic domestic clothes washing machine set in the spin-dry cycle. The writers have reported one set of data obtained by this method before tests as adequate as those reported here were made[2].

The machine available to us is an old model with no device for control of speed of revolution of the tub around its vertical spindle. To determine actual speed, a temporary lid was cut of corrugated paper board with a central hole to permit pressing a Jacquet's Indicator against the revolving tub spindle. Speed determinations, during nine consecutive experimental spinnings of a series of 12 root systems, showed that this machine quickly accelerates to about 390 rpm and continues to accelerate moderately during 5 minutes. Also, acceleration occurs more rapidly and to higher maximum speeds after the machine has run long enough to warm up. The highest speed recorded, after 4 minutes 50 seconds in the final spin of a series of tests that had warmed the machine thoroughly, was 440 rpm. For this machine a suitable procedure is to start when it is cold, allow it to spin empty for 5 minutes, stop it and add the roots, then spin them for 5 minutes. Speeds of 410 to 430 rpm are attained. The radius of the tub is 26.5 cm. Assuming an effective radius of 25 cm to the centers of the root packets, the force developed at a speed of 420 rpm is approximately 49 times gravity.

To obtain roots suitable for experimental comparison of this method with that of draining and blotting, 12 corn plants were grown 4 weeks from seed in separate 6-inch pots of a sand-soil-manure mixture. Tops were cut off at the soil surface and the roots were washed thoroughly and kept in water until all were ready. Each root system with an identifying number was then folded and wrapped into a compact flat packet with muslin, and returned to water until ready for the test.

The 12 packets of wet roots were then leaned against the side wall of the spinner tub; they were distributed uniformly to maintain balance. The lid was put on, the machine was allowed to spin the desired period of time, then the packets were removed one at a time, unwrapped, and the roots weighed immediately. In preparation for the next spinning the roots were wrapped again and immersed in water while the others were being weighed. In this way all 12 roots were weighed after three spinnings each of 1 minute, 3 minutes and 5 minutes duration. Fi-

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[2] Rhoades, Harlan L., and M. B. Linford. 1959. Control of pythium root rot by the nematode Aphelenchus avenae. Plant Disease Reptr. 43: 323-328.

nally, each was subjected to three consecutive determinations of blotted weight. All weights were recorded to the nearest 0.1 gram.

This test showed that 5 minutes of spinning gave the most consistent and lightest weights, being only a little better than the shorter periods of spinning but much better than the blotting. Mean weights determined after spinning 1, 3, and 5 minutes were 19.4 gm, 18.9 gm, 18.5 gm, respectively, compared with 20.9 gm after blotting. Using the greatest weight discrepancy between the three consecutive determinations with one method as a measure of consistency, 5 minutes of spinning gave a maximum discrepancy of 0.2 gm and blotting a maximum of 1.9 gm. Means of the greatest discrepancies for the 12 root systems were 0.11 gm and 0.62 gm for the 5 minutes spin and the blotting, respectively.

Another test for consistency was made with roots of Turkish tobacco grown 3 months in 6-inch pots. During this period the plants had grown to the blossoming stage, had been uniformly cut back and had made strong second growth. Roots of nine plants, representing three replicates of three treatments from a nematode pathogenicity test, were washed thoroughly, wrapped in muslin, spun 5 minutes, then weighed. They were again wrapped as before and immersed in water about 20 minutes before being spun and weighed again. Blotting these root systems, consisting of great masses of fibrous roots, would have been very difficult and time consuming, and no blotted weights were determined.

These nine tobacco root systems ranged in weight from 46.1 gm to 72.7 gm, with a mean of 63.6 gm after the first 5-minute spin. After the second spin the mean was reduced about 0.5 percent to 63.3 gm. All but one sample weighed less after the second than the first spin, the maximum difference being 0.6 gm or about 1 percent, and the mean reduction per three plants of a treatment was uniformly 0.3 gm. This is judged to be much more consistent than would have been possible with blotting. Part of the decrease in weight shown after the second spinning probably resulted from removal of additional soil from the roots, because after both spinnings the muslin retained soil that had come off of the roots.

On the basis of these tests and of use of the method in several experiments with nematodes, we judge that mild centrifugation of washed roots prior to weighing yields more reliable data on moist weights than are otherwise obtainable. Spinning a batch of roots takes little time, and as many as 12 root systems of celery, weighing from 158 to 202 grams each, have been spun at one time.

Lack of speed control on the machine used by us has made it impossible to determine what speed might be best for this purpose. Tub diameter and revolutions per minute will not be uniform between different makes and models of washing machine spinners; therefore preliminary trials to determine the characteristics of a machine would be advisable before putting one to use in this way. Provided that constant speed and duration of spinning can be achieved, consistent results can be obtained even though they bear no constant relationship to dry weights. Minor differences in speed at different times should cause no serious trouble statistically provided that equal numbers of replicates of all treatments of a given experiment are included in each spin.

Active, live nematodes have been seen within roots following such spinning, and nematodes have been extracted from spun roots.

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A POSSIBLE ASSOCIATION OF NEMATODES WITH THE SPREAD OF PEACH YELLOW BUD MOSAIC VIRUS

James R. Breece and W. H. Hart[1]

The virus which causes yellow bud mosaic of peach was shown by Wagnon and Breece (4) to be retained in the soil where infected peach trees have grown. When they planted peach seeds in cans of soil within a few days after the soil was taken from the root zone of yellow bud mosaic-infected orchard peach trees, some of the resulting seedlings developed yellow bud mosaic symptoms, usually within a year. Previously, it was observed that healthy young nursery-grown peach trees became infected in the field after being planted and grown in soil from which infected peach trees had been removed.

Thomas et al. (3) observed that in several orchards the disease undoubtedly is perpetuated by replanting peach trees among or adjacent to older trees. They stated that observed facts seemed to indicate that the vector has a very limited range of movement.

The localized spread-pattern of peach yellow bud mosaic in the field, from tree to adjoining tree, has suggested underground spread and an underground vector.

In work by Wagnon and Traylor (5) peach seedlings did not become infected when planted in cans of soil taken from around the roots of infected peach trees after the soil had been treated. They divided the soil into six lots, each lot containing ten 1-gallon cans. Each lot received one of the following treatments: 1) Nemagon (97% 1,2-dibromo-3-chloropropane), 0.5 ml by injection; 2) carbon bisulfide, 50 ml (in a sealed container); 3) Vapam (sodium N-methyldithiocarbamate), 10 ml mixed with the soil in a sealed container; 4) methyl bromide, 5 pounds per 1000 cubic feet of container space for 24 hours; 5) D-D (1,3-dichloropropene; 1,2-dichloropropane), 1 ml; or 6) steam, 20 pounds/square inch for 1 hour.

In 1956, during exploratory examination in the laboratory of soil from the root zones of yellow bud mosaic-infected peach trees, low populations of several genera of nematodes were found by the Baermann funnel technique. Two genera of plant parasitic nematodes were present, namely Pratylenchus and Xiphinema, the latter being the more abundant. Nematodes of the species Xiphinema americanum Cobb consistently were present. When a collection of Xiphinema americanum, obtained by the Baermann funnel technique, from soil from the root zone of peach trees infected with yellow bud mosaic was applied to the root zone of healthy young peach seedlings grown and kept in a greenhouse except during dormancy, no yellow bud mosaic symptoms developed in the peach seedlings during the same or the subsequent growing season.

In May of the following season (1957), when a collection of nematodes of the genus Xiphinema was recovered by the sieve method from similar soil and applied to the roots of healthy young peach seedlings, symptoms later appeared. The soil was taken separately from the root zone of each of two yellow bud mosaic-infected peach trees in a commercial orchard. The soil from each tree was processed separately by the sieve method to extract nematodes belonging to the genus Xiphinema and in each case was thoroughly mixed with cold tap water in a pan, and the mixture poured onto soil sieves. The residues caught on the sieves were examined in syracuse dishes under a dissecting microscope. Nematodes of the genus Xiphinema, believed to be of the species X. americanum, were picked out with a nylon bristle and placed in clean tap water. They were transferred a second and a third time to clean tap water and applied in the final water to the root zone of healthy young peach seedlings which were growing in 1-gallon cans of clean potting soil. The nematodes obtained from the soil from each of the two trees were handled separately.

One hundred twenty of the nematodes (all living), obtained from the soil from one tree, were introduced on May 27, 1957 into one of the 1-gallon cans, which contained a single peach seedling. The seedling developed severe symptoms of yellow bud mosaic about 10 months later, in March 1958.

Ninety of the nematodes (all living), obtained from the soil from the other tree, were introduced on May 28, 1957 into another 1-gallon can, which contained four of the peach seedlings. Yellow bud mosaic symptoms were observed on one of the four seedlings in October

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1957, about 5 months after inoculation. In March 1958, this seedling and two additional seedlings in the can showed severe symptoms of yellow bud mosaic, and the fourth seedling had symptoms that suggested yellow bud mosaic.

Other peach seedlings, of the same age and source, growing in similar clean potting soil in cans to which no nematodes were applied, did not develop symptoms of peach yellow bud mosaic.

Hewitt, Raski, and Goheen (1, 2) showed that the fanleaf virus of grape can be transmitted by X. index Thorne and Allen, a different species from the one herein discussed. The work reported here suggests nematode transmission of peach yellow bud mosaic virus by X. americanum.

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DESTRUCTION OF INOCULUM OR POSSIBLE TRANSMITTING AGENT OF PEACH ROSETTE MOSAIC VIRUS BY SOIL DRENCHING WITH CHLORDANE[1]

Robert H. Fulton and Donald Cation

In 1933, Cation[2] reported that a disorder of peach described as rosette mosaic was infectious and could be transmitted readily by the transfer of soil from the root environment of dis-

FIGURE 1. Halehaven peach seedlings. Left, grown in chlordane treated soil, healthy; Right, in untreated soil, showing typical rosette mosaic symptoms.

[1]Contribution No. 59-16, Department of Botany and Plant Pathology.

[2]Cation, D. 1933. An infectious rosette of peach trees. Michigan Agr. Exp. Sta. Quar. Bull. 16: 79-84.

eased trees to that of healthy peach trees. However, this did not preclude the transfer of insects or nematodes in the soil complex. Insect transmission studies[2] using the black peach aphid, Anuraphis persicae-niger, failed to result in typical disease expression. Since several other insect pests are common to the root environment of peach, it was deemed favorable to initiate a test to determine if a soil insecticide would prevent transmission.

Soil samples were obtained from the root environment of peach trees showing severe symptoms of rosette mosaic. The affected soil complex was thoroughly mixed and divided into two lots. One lot was drenched with tap water, the other with a 0.5 solution of chlordane. Peach seedlings, grown from Halehaven pits, were potted using sterilized soil as a check in addition to the untreated and treated soil lots.

No symptoms of rosette mosaic were evident the first growing season. In order to break dormancy, the potted trees were held in cold frames until late January, then removed to the greenhouse. When the first leaves were well developed on check trees, noticeable symptoms of rosette mosaic were evident on the trees growing in the untreated soil. Fourteen of the 16 trees (87 percent) exposed to untreated soil showed severe symptoms (Fig. 1). All of the seedlings in the check and chlordane treated soil displayed normal growth and no symptoms of virus infection.

This test further corroborates the report on the transmission of rosette mosaic by means of contact with a diseased soil complex. However, until further evidence is obtained, the lack of transmission in chlordane treated soil could be the result of destruction of insect or other biological vectors, inactivation of the virus in the soil, or the conditioning of the tree by chlordane acting as a therapeutant against the virus.

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TIME AND TEMPERATURE REQUIREMENTS FOR THE TRANSMISSION OF THE NECROTIC RING SPOT VIRUS OF PRUNUS[1]

Paul R. Fridlund[2]

Abstract

The time required for transmission of the necrotic ring spot virus from infected buds to test trees depends upon temperature. At 30° C the time of tissue contact required is 72 hours, whereas at 18° it is 168 hours. The particular culture of a virus and the host source play some part in the rapidity of transmission, but probably neither is very important.

In the process of indexing Prunus trees for latent and masked virus diseases, it is necessary to transmit the virus from the tree in question to diagnostic indicator hosts. The indicator hosts are mainly other kinds of trees and such transmissions are made by budding or grafting suspect tissue onto the indicators. Suitable mechanical techniques are not known for efficient tree-to-tree transmissions. It is common knowledge that attempted virus transmissions occasionally fail, and one frequent conclusion has been that the inoculum-containing tissue died before transmission occurred. On the other hand, transmissions have occurred when observations indicated that the inoculum-containing material apparently died soon after being budded or grafted onto the indicator host. To the author's knowledge no thorough study of the time of tissue contact necessary for transmission of any Prunus virus has been reported in the literature, although several very brief statements regarding a few viruses do occur. Thus Gilmer (2) briefly mentioned 96 hours as the minimum contact period for transmission of the necrotic ring spot virus in Prunus, the virus used in the present experiments. Accordingly, two experiments were made to study in detail the following in relation to necrotic ring spot virus transmission: 1) Hours of tissue contact necessary for transmission; 2) Relationship between temperature and minimum time of tissue contact; 3) Possible differences between culture of necrotic ring spot virus; 4) Possible differences between different sources of the same virus culture (for example, from host species compatible and noncompatible with the test plant).

Virus-free yearling Prunus tomentosa trees about 1/4 inch caliper were planted in 6-inch pots, pruned to a single whip 12 inches high, and were allowed to break dormancy in the greenhouse at 26° C. Trees were potted in excess of those needed so that test trees could be selected for uniformity. All trees, except noninoculated controls, were inoculated simultaneously at bud break with one virus-containing bud. The bud was chip-budded midway on the whip and tied with a commercial budding rubber. Immediately upon budding, the trees were placed in different sections of a greenhouse maintained at constant temperatures of 30°, 26°, 22°, and 18° C with extreme variations of less than $\pm$ 2°. The buds, except those on inoculated control trees, were removed at 24-hour intervals commencing after 72 hours contact. Because the greenhouse humidities were low, the exposed surfaces resulting from bud removal dried rapidly, allowing little chance for live residue from the bud to remain. Symptom appearance was recorded commencing 8 days after inoculation and continued for 30 days. At the end of this period all symptomless inoculated plants were reindexed to determine if transmission had occurred without causing symptoms.

Two virus cultures known locally as #2 and #7 were used. They originated and were available in Prunus mahaleb, and also P. tomentosa. Culture #2 consisted of necrotic ring spot virus and prune dwarf virus. Culture #7 consisted of necrotic ring spot virus, prune dwarf virus, and sour cherry yellows virus. No other known viruses were present in the cultures as determined by extensive indexing. Culture #2 caused very mild symptoms and culture #7 caused mild symptoms in P. tomentosa. The symptoms of necrotic ring spot in P. tomentosa have been described (1), but distinct symptoms in that host of prune dwarf and sour cherry yellows in the absence of necrotic ring spot are not known.

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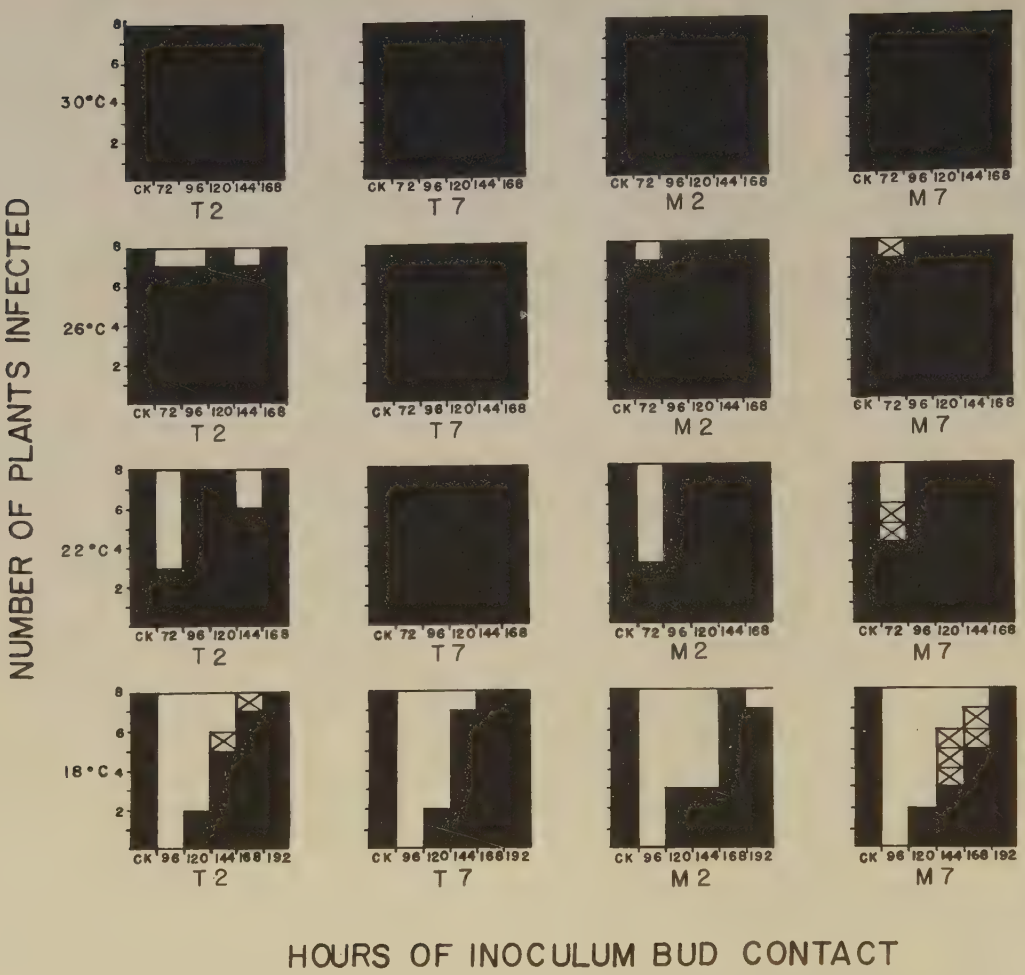

FIGURE 1. Hours of inoculum bud contact and number of Prunus tomentosa trees becoming infected with the necrotic ring spot virus when kept at four temperatures.

Eight replicates of each treatment were used in the first experiment. The treatments consisted of 1) six times of bud contact, 2) two virus cultures each from two different host species, and 3) exposure at four temperatures. A total of 738 plants exclusive of noninoculated controls were used. Bud removal at 30°, 26°, and 22° C commenced after 72 hours and at 18° C after 96 hours contact. The results of this experiment are shown in Figure 1.

Every inoculated plant kept at 30° became infected. Of those at 26° all became infected except two at 72 hours and two other probable escapes. This same pattern continued at 22°, but a more noticeable lack of transmission at 72 hours was evident. At 18° consistently good transmission was not obtained until 168 hours. Except at 30°, in every case of comparable transmission, for example, where temperatures and host source were the same, culture #7 infected a few more plants than did culture #2. In addition, slightly more transmission was obtained with cultures #2 and #7 from P. tomentosa than from P. mahaleb.

Because all plants became infected at 30°, the second experiment was made to determine the threshold for infection at this temperature. The procedures were identical with those of the previous experiment. Seven replicates of each of three virus sources were compared at four times of bud contact. All 84 trees were maintained at 30°. The results of this experiment are shown in Figure 2.

With one exception all control trees and those with bud contact of 72 hours became infected. A few in each test at 48 hours also became infected, but no transmissions occurred in the 24-hour treatment. Culture #7 again infected slightly more plants than culture #2. As in the

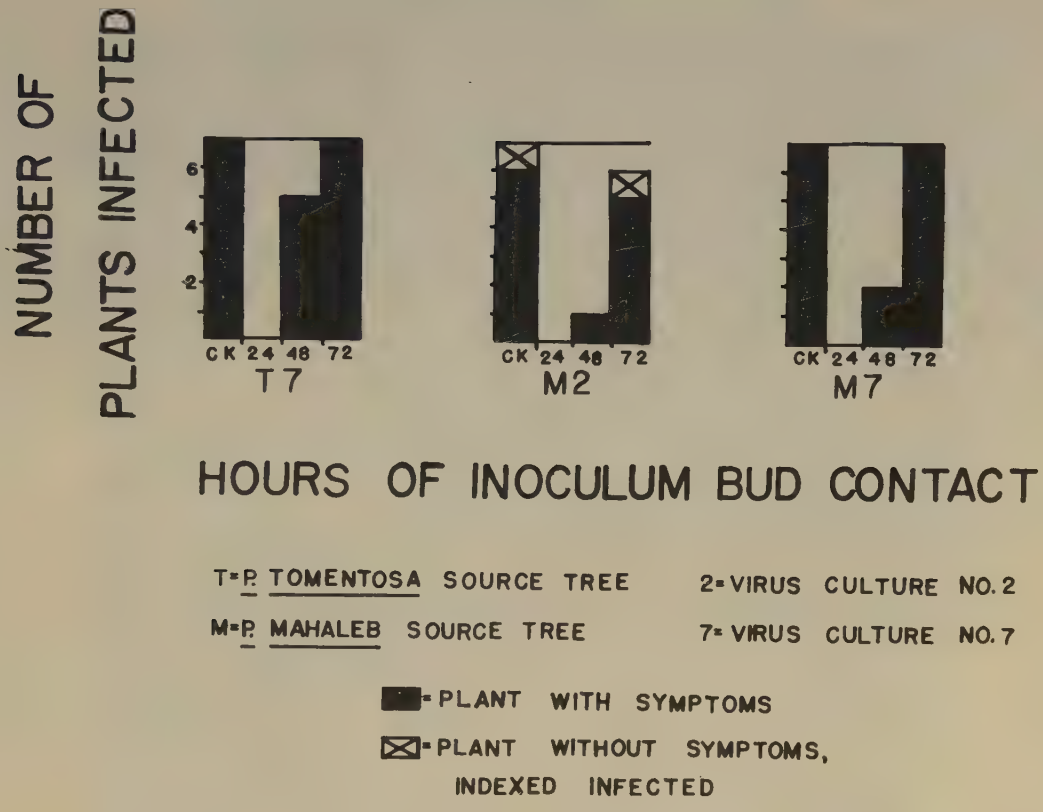

FIGURE 2. Hours of inoculum bud contact and number of Prunus tomentosa trees becoming infected with the necrotic ring spot virus when kept at 30° C.

previous experiment, slightly more plants became infected when the source was P. tomentosa, than when it was P. mahaleb.

In conclusion, it appears that at any constant normal greenhouse temperature, latent Prunus virus transmission will occur if the inoculum bud remains in contact with the inoculated plant for 168 hours. At temperatures of 22° to 30° C a 96-hour contact appears sufficient. At 30° and possibly higher temperatures only 72 hours are needed. The particular culture of virus and the host source play some part in the relationship of contact time versus temperature, but probably neither is very important. However, a more severe-reacting virus appears to infect more plants at a given temperature and with a given time of contact than a milder-reacting virus. A compatible bud-host combination also results in slightly more transmission than a noncompatible combination.

These data confirm that mere mechanical transmission was not involved, a conclusion that is generally accepted. Mechanical transmission, if present, should have occurred consistently at the shorter periods of bud contact as shown for 96 hours at 18° in Figure 1 and 24 hours in Figure 2. One must assume that such transmission would occur early when the wounds on both the host and the inoculum source were fairly fresh. Therefore, some sort of tissue union between bud and host must have taken place to accomplish infection even though the two are considered horticulturally incompatible.

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OUTBREAK OF WITCHES' BROOM DISEASE IN PUGET BEAUTY STRAWBERRY IN OREGON[1]

P. W. Miller[2]

In 1927 Zeller (2) described a new virus disease of Ettersburg strawberries in Oregon which he named witches' broom. Subsequently, this virus disease practically disappeared, and its presence has not been definitely reported since from the Pacific Northwest up to the time of the present note.

In February 1959, however, this same disease was again found in a field of Puget Beauty strawberries growing in Clackamas County, Oregon. The diseased plants were dwarfed and "bushy" in appearance, with multiple-branched crowns (Fig. 1, A). The disease was confined to the Puget Beauty variety in one field.

FIGURE 1. Witches' broom virus disease of strawberry: (A) in Puget Beauty variety; (B) in Fragaria vesca var. alpina, transmitted from (A) to (B) by grafting (excised-leaf-petiole graft technique).

Excised leaves from typical specimens were grafted to Fragaria vesca var. alpina seedling indicators and to several plants of the Marshall variety using the excised-leaf-petiole graft technique (1). The grafted vesca indicator plants became very "bushy" and had multiple-branched crowns and a multiplicity of small leaves with spindly petioles. (Fig. 1, B). The inoculated Marshalls likewise had multiple-branched crowns and small leaves (Fig. 2). The disease is therefore considered the same as the witches' broom disease of Ettersburg described by Zeller.

In the disease called stunt (3)--a virus disease with which this might be confused--the petioles are shorter and the plant is more stunted.

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[1]Cooperative investigations by Crops Research Division, Agricultural Research Service, United States Department of Agriculture and Oregon Experiment Station.

[2]Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

FIGURE 2. Witches' broom virus disease in the Marshall strawberry variety; transmitted from an infected Puget Beauty plant (Fig. 1, A) by excised-leaf-petiole grafts.

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PHYSIOLOGIC RACES OF THE LEAF RUST OF WHEAT, PUCCINIA RECONDITA ROB. EX DESM., IN THE UNITED STATES IN 1958[1]

C. O. Johnston[2]

Summary

Twenty-eight physiologic races of Puccinia recondita were isolated from 295 collections of leaf rust made in 28 States of the United States in 1958. Race 15 was the most abundant for the second consecutive year, followed in order by races 5, 122, 2, 11, and 6. Races 11, 26, 131, 1, and 53 were most abundant in the Pacific Coast region. Race 6 and similar races were most abundant in the north-central region. Race 58 was abundant only in New York. Races 68, 84, 93, 130, 141, and 143 were unimportant, being isolated only once or twice each.

Leaf rust of wheat, Puccinia recondita, was collected at many places in the United States in 1958 and sent to Manhattan, Kansas for physiologic race analyses. Cultures from 295 collections represented 28 States. These yielded 943 sub-cultures, which revealed the presence of 28 physiologic races. The results obtained are shown in Table 1.

Race 15, for the second consecutive year, was the most abundant and widely distributed race, representing 31.1 percent of all races and appearing in all but six States. The similar race 2, comprising 7.3 percent of all isolates, also was abundant. These two races comprising unified race 2 thus represented 38.4 percent of all isolates.

Race 5, comprising 12.3 percent of all isolates, was second in abundance. It was isolated from collections made in 18 States but was particularly abundant in Arkansas, Iowa, Kansas, Minnesota, Nebraska, Oklahoma, and South Dakota.

Race 122 was third in abundance, representing 8.7 percent of all isolates. It also was widely distributed, occurring in 18 of the 28 States from which samples were analyzed. Unified race 13 comprising races 35, 54, 77, and 122 represented 13.4 percent of all isolates. Race 122 was by far the most important race in Georgia and South Carolina and also was important in Arkansas, Illinois, Missouri, and Texas.

Race 11, the principal constituent of unified race 10, was fifth in prevalence, comprising 5.7 percent of all isolates. Race 11, with the similar races 26 and 131, comprised 8.7 percent of all isolates. These races were particularly abundant in California, Oregon, Washington, and Idaho. However, one or more of the races were found in eight other States.

Race group 9, including the similar races 9, 10, 19, and 20, jointly comprised 10.4 percent of all isolates, although none of them was very important individually. Race 9 and race 20 each comprised 3.7 percent of all isolates. One or more races of the group were especially important in Kansas, Minnesota, Nebraska, New Mexico, Oklahoma, and Texas.

Race 6, the principal constituent of unified race 6, was only eighth in abundance but was important in certain States. Race 105 was only slightly less abundant. The unified race 6 group, composed of races 6, 28, 105, and 126, comprised 9.8 percent of all isolates. Race 6 and/or 105 were most abundant in Iowa, Kansas, Minnesota, Michigan, Missouri, Nebraska, and South Dakota.

Race 1 and the similar race 53 were especially abundant in Idaho and Washington. However, race 1 was isolated also from collections made in Arkansas, Kansas, and North Dakota.

Race 58 was isolated from collections from nine States but was abundant only in New York.

Six minor races were isolated only once or twice each. These were races 68, 84, 93, 130, 141, and 143. Data on these are shown at the bottom of Table 1. The isolates of these were included in the total number of isolates used to calculate the percentage of total isolates for each race shown in the table.

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[1]Contribution No. 537, serial No. 692, Department of Botany and Plant Pathology, Kansas Agricultural Experiment Station, Manhattan, in cooperation with the Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, KANSAS STATE COLLEGE, MANHATTAN IN COOPERATION WITH CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

Table 1. Physiologic races of Puccinia recondita isolated from collections of leaf rust of wheat made in the United States in 1958.

State	Number of isolates of unified races and of constituent physiologic races[a]																							Total Number		
	1		2		3	5		6				9				10			13					Isolates	Races	Collections
	1	53	2	15	58	5	52	6	28	105	126	9	10	19	20	11	26	131	35	54	77	122				
Alabama			2	6			2							1		1				4				16	6	8
Arkansas	3		7	22		6	2			1			1		2							3		47	9	12
California			1					1							1	9	2	6	1					21	7	8
Colorado				8		1				1		1		1						2		1		15	7	4
Florida																1				3				4	2	2
Georgia			2	11		1				1										5	1	15		36	7	13
Idaho	10	4		3	1											14	5	7				2		46	8	12
Illinois			3	8	1	2		2		3					1				1		1	9		31	10	9
Iowa			3	11		12		14		8				2	1					1		4		56	9	16
Kansas	2		34	75	1	40	6	10	2	3		20		4	8	5	3			2	1	9		225	17	68
Michigan				11										1								2		14	3	8
Minnesota			1	13	1	9	1	4	1	3				3	2	1			1	1		3		44	14	14
Mississippi				1												2				3		2		8	4	3
Missouri			2	3			1		1						1						1	3		12	7	3
Nebraska				6	1	8		2	2	4		2		3	3					2	1	1		35	12	11
New Mexico			2	5		1		1				4		4	2						1	1		21	9	5
New York					6											1		1			1			9	4	3
North Dakota	1		2	11		2		3										1						20	6	7
Oklahoma			3	8	1	6					2	2		3										25	7	9
Oregon					1	1							1			11								14	4	3
Pennsylvania				9				1		1		1								1		1		14	6	4
South Carolina				21	1	5				1				1						3	1	17		50	8	16
South Dakota				14		11		2	2	2	1										1	3		36	8	10
Texas			6	28		7	2	4	2	1	1	3			10	1				1		5		71	13	25
Virginia				13		1		1		2		1		2	1				3					24	8	10
Washington	7	3				1	1					1			1	8	2	1				1		26	10	7
Wisconsin				6		2			1	1										1				11	5	4
Wyoming			1											1	2									4	3	1
Total	23	7	69	293	14	116	15	45	11	32	4	35	2	26	35	54	12	16	6	29	9	82		935		295
Percentage of total isolates	2.4	0.7	7.3	31.1	1.5	12.3	1.6	4.8	1.2	3.4	0.4	3.7	0.2	2.8	3.7	5.7	1.3	1.7	0.6	3.1	1.0	8.7				

[a]Also identified were the following new or unimportant races: 68 = UN12, North Dakota (1); 84 = UN3, South Carolina (1); 93 = UN11, South Carolina (1); 130 = UN13, Illinois (2); 141 = UN3, Minnesota (1); 143 = UN17, Minnesota (1); Kansas (1).

PHYSIOLOGIC RACES OF BARLEY LEAF RUST (PUCCINIA HORDEI) ISOLATED IN THE UNITED STATES FROM 1956 THROUGH 1958[1]

J. G. Moseman and C. W. Roane[2]

Abstract

During the 3 years 1956 through 1958, six physiologic races of leaf rust (Puccinia hordei Otth.) were isolated from barley grown in the United States. About 70 percent of the cultures obtained were race 4. In addition to the nine standard differential varieties of barley, seven supplemental varieties which have been outstanding for resistance to leaf rust when grown in the Uniform Rust Nurseries and the International Barley Disease Nurseries and Little Club Wheat were inoculated with seven cultures of the pathogen isolated from barley grown in the United States in 1958 and with a culture of race 4 isolated in 1955. Two of the supplemental barley varieties, Cebada Capa (C. I. 6193)[3] and Aim (C. I. 3737), were resistant to all eight cultures and may be of value as parents for incorporating leaf rust resistance into commercial varieties. The wheat variety Little Club was immune from infection by all 39 cultures of P. hordei studied.

The rust fungi are known to vary greatly with respect to pathogenicity. It is very important that these changes in pathogenicity be detected so that plant breeders can develop and maintain resistant varieties. These changes can be determined by a coordinated study of the host and the pathogen. New pathogenic strains can be detected by looking for susceptible type pustules on selected varieties with known combination of genes conditioning resistance and additional varieties outstanding for resistance to barley leaf rust in the field. To isolate these pathogenic strains, collections should be made of susceptible type pustules from these selected varieties and the cultures tested under controlled conditions.

The data in this paper were obtained from tests with leaf rust isolated from barley grown in the U. S. D. A., Uniform Rust Nurseries and other special nurseries. In addition, a comparison of the reactions of a supplemental group of seven selected varieties and of the nine varieties used as standard differentials in North America when infected with the seven cultures of the pathogen isolated from barley grown in 1958 and a standard culture of race 4 is included.

The history of physiologic race identification in North America was summarized by Levine and Cherewick (2) in 1952 and the genetics of resistance in the host was studied by Henderson (1), Waterhouse (4), Zloten (5), and Starling (3). In the four independent genetic studies it was found that many varieties have the same genes conditioning resistance. Henderson found that the eight varieties Weider (C. I. 1021), Bolivia (C. I. 1257), Purple Nepal (C. I. 1373), Modia (C. I. 2483), Morocco (C. I. 4975), Barley 305 (C. I. 6015), Ricardo (C. I. 6306), and Marco (C. I. 5647) had the same gene for resistance, which he designated Pa. The variety Estate (C. I. 3410) had a different gene conditioning resistance, which he designated Pa_1. Waterhouse observed that the three varieties Manchuria, Virginia Hooded, and Hordeum distichon ramparii typica each had a single dominant gene conditioning resistance. Zloten found that each of the varieties Kwan (C. I. 1016) and Ricardo (C. I. 6306) had two genes conditioning resistance to leaf rust. The major genes in each of these varieties were completely dominant and independently inherited. A second incompletely dominant gene was common to the two varieties. Starling observed no plants susceptible to a culture of race 4 of P. hordei,

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[3]C. I. refers to the accession number of the Cereal Crops Research Branch, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

from the crosses of resistant Peruvian (C. I. 935) with Batna (C. I. 3391), Ricardo (C. I. 6306), Carre 180 (C. I. 3390), C. I. 3530-2, and C. I. 3895-2; this indicated that all of these varieties have a factor for resistance in common presumably at the Pa locus. Susceptible plants were obtained from crosses of resistant Cebada Capa (C. I. 6193) and Ariana (C. I. 2524) with resistant Peruvian, indicating these two varieties have a factor for resistance at a locus other than the Pa locus. Cebada Capa was the only variety in which resistance was completely dominant.

MATERIALS AND METHODS

The varieties used in this study were those which Levine and Cherewick (2) used as standard differentials and seven additional varieties which have been resistant to leaf rust in the Uniform Rust Nurseries and International Barley Disease Nurseries. The nine standard differential varieties were obtained from Levine. The special varieties were furnished from the World Collection of barley maintained by the United States Department of Agriculture. The wheat variety Little Club was included in all the tests to determine whether leaf rust of barley would infect this variety of wheat.

The cultures of the pathogen were obtained from susceptible type pustules on leaves of plants which were furnished by cooperators in the Uniform Rust Nursery and International Barley Disease Nursery Program[4]. When received, the leaves were stored in a refrigerator at 34° F.

The methods of inoculating and recording the infection types were as follows: In the afternoon, urediospores collected earlier in the day were mixed with talc and dusted on leaves of plants which had been sprayed with a fine mist of water. The plants were placed in an incubator at 65° to 70° F and free water was maintained on the leaves overnight. The following morning the sun was permitted to warm the incubator to about 80°. The plants were then placed in a greenhouse at about 70°. In 14 to 16 days the infection types were recorded on a scale of 0-4, indicating the pustule size from no pustules to large pustules. The letters and symbols indicate the following: ; = fleck, N = necrosis, C = chlorosis, H = halo with necrosis (usually associated with pustule size 2), C-N = chlorosis at the base of the leaf and necrosis toward the top.

RESULTS

The data in Table 1 show the frequency with which a given physiologic race of P. hordei

Table 1. Physiologic races of Puccinia hordei isolated from barley plants grown in the United States during 1956-1958.

Year and State of origin	Frequency of cultures of physiologic race						Total	
	4	16	34	40	44	45	Cultures	Races
1956								
Wisconsin	2					2	4	2
Michigan	4						4	1
New York	5						5	1
1957								
Mississippi	3						3	1
N. Carolina	2						2	1
Virginia	2	4					6	2
Illinois	1			1			2	2
N. Dakota			1				1	1
Michigan	2			1			3	2
New York	2						2	1
1958								
Michigan					1		1	1
New York	4			1	1		6	3
Total	27	4	1	3	2	2	39	6

[4]The authors wish to express their appreciation to those who cooperated by collecting and sending leaves of plants with susceptible type pustules.

Table 2. Seedling reaction of 16 barley varieties to infection with cultures of Puccinia hordei isolated from barley grown in the United States in 1958 and a culture of race 4 isolated in 1955.

Variety[b]	C.I. No.	Infection type[a] with culture of physiologic race							
		1955 Race 4	Cult. 9 Race 4	Cult. 11 Race 4	Cult. 12 Race 4	Cult. 13 Race 4	Cult. 8: Race 40	Cult. 10: Race 44	Cult. 33: Race 44
*Speciale	7536	1N	1N	1N	0-1N	1N	1N	1N	1N
*Sudan	6489	1N	1N	1N	0-1N	1N	1N	1N	1N
*Oderbrucker	940	1N	1N	1N	1N	1-2N	1N	1N	1N
Cebada Capa	6193	1N	1N	1-2N	1N	1N	1N	1N	1N
*Lechtaler	6488	1N	1N	1-2C-N	1-2C-N	1N	3-4	0-1N	1N
Franger	8811	1N	1-2C-N	1-2C-N	1-2C-N	1N	3-4	1N	1N
Hispont	8828	1N	1N	1-2N	1-2N	1N	4	0-1;	1N
*Gold	1145	0-1;	0-1;	0-1;	0-1;	1N	4	0-1;	0-1;
*Reka 1	5051	1-2C-N	1-2C-N	1-2C-N	1-2C-N	1-2C-N	1-2C-N	3-4	4
Ariana	2524	1-2C-N	1-2C-N	1-2C-N	1-2C-N	1-2C-N	1C-N	3-4	3-4
Ricardo	6306	1-2C-N	2H	2H	1-2C-N	1-2C-N	1-2C-N	3-4	4
Marocaine 079	8334	1-2C-N	1-2C-N	1-2C-N	2C-N	1-2C-N	1-2C-N	4	3-4
*Bolivia	1257	1N	0-1N	1-2C-N	0-1N	1-2C-N	1C-N	2H	2H
*Quinn	1024	1-2C-N	1-2C-N	1-2C-N	1-2C-N	1-2C-N	1C-N	2H	2H
Aim	3737	0-1;	0-1;	0-1;	0;	0-1;	0-1;	0-1;	0-1;
*Egypt 4	6481	4	4	4	4	4	4	4	4

[a]Infection types as follows: Numbers 0-4 indicate size of pustules from no pustules to large pustules. The letters and symbols indicate: ; = fleck, N = necrosis, C = chlorosis, C-N = chlorosis base leaf necrosis at tip, H = halo with necrosis.

[b]Varieties marked with an asterisk (*) are the varieties used as standard differentials in North America.

was isolated from plants grown in the United States during the years 1956-1958 inclusive. Physiologic race 4 made up about 70 percent of all the cultures. Race 16 was obtained from only Virginia from plants of differential varieties resistant to physiologic race 4. Races 34, 40, 44 and 45 were isolated 1, 3, 2, and 2 times, respectively.

The infection types produced on 16 varieties of barley and Little Club wheat when inoculated with seven cultures of P. hordei isolated from barley grown in the United States in 1958 and a culture of race 4 isolated in 1955 are shown in Table 2. Included in the 16 varieties are 9 which have been used as the standard differentials in North America and 7 selected varieties which have been outstanding for resistance to leaf rust in the field when grown in the Uniform Rust Nurseries and International Barley Disease Nurseries. Several of the varieties reacted similarly to infection with these cultures. The three differential varieties Speciale, Sudan, and Oderbrucker and variety Cebada Capa were resistant to all the cultures and had similar reactions to infection. The differential variety Lechtaler and the two varieties Franger and Hispont were susceptible only to culture 8 of race 40, as was the variety Gold, but they had a reaction differing from that of Gold to some of the other cultures. The differential variety Reka 1 and the varieties Ariana, Ricardo, and Marocaine 079 were susceptible only to cultures 10 and 33 of race 44 but reacted like the varieties Bolivia and Quinn when inoculated with the other cultures. The variety Aim had the highest type resistance of all the varieties to all cultures. The variety Egypt 4 was susceptible to all the cultures. The wheat variety Little Club was found to be immune from infection by all the cultures of leaf rust tested during these 3 years.

DISCUSSION AND CONCLUSIONS

The 39 cultures of Puccinia hordei isolated from barley grown in the United States in the years 1956, 1957 and 1958 did not vary greatly in their pathogenicity on the 16 varieties studied. The fact that over 70 percent of the cultures were race 4 agrees with earlier studies by Levine and Cherewick (2), who also found this race to predominate. None of the cultures were highly pathogenic on four of the nine standard differential varieties. This indicates a lack of pathogenic variability on these varieties.

The similarity in the reaction of certain varieties to infection by these cultures indicates that these varieties may have the same gene conditioning resistance to these cultures of the pathogen. By crossing these varieties and inoculating the progenies with a culture of race 4, the relationship of the genes in the varieties can be determined. Another technique that could be applied would be a genetic study of the pathogenicity of progenies from crosses of various cultures of the pathogen on these varieties.

Since the variety Aim was more resistant to all the cultures than were the other varieties, it apparently has a gene conditioning resistance to these cultures not present in the other varieties.

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STRAIN DYNAMICS OF POWDERY MILDEW OF BARLEY, ERYSIPHE GRAMINIS F. SP. HORDEI, IN NORTH AMERICA

John G. Moseman[1]

Abstract

New pathogenic strains of Erysiphe graminis DC. f. sp. hordei Em. Marchal were isolated from cleistothecia on plants grown in British Columbia and Ontario, Canada and northeastern United States. The cultures from British Columbia were all classified as physiologic race 3. They were similar in pathogenicity to cultures of race 3 previously isolated from that area, except that they were pathogenic on the three varieties Rabat (C.I. 4979)[2], Algerian (C.I. 1179), and Marocaine 079 (C.I. 8334) which had been immune from or highly resistant to cultures from North America in all previous tests. The cultures from northeastern United States and Ontario, Canada were pathogenically similar to cultures of the predominant races 8 and 9 previously isolated from that area, except for their pathogenicity on the varieties Modia (C.I. 2483), Ricardo (C.I. 6306), Goldfoil (C.I. 928), and Stephan (C.I. 8051). In 1956 and 1957 cultures pathogenic either on Modia and Ricardo or on Goldfoil and Stephan were isolated. In 1958 cultures pathogenic on all four varieties were isolated. Since Goldfoil is one of the six standard varieties used in differentiating physiologic races, one of the cultures was pathogenically different from those previously isolated in North America. This culture was designated as physiologic race 21. The reasons for expecting that Goldfoil and Stephan have the same gene conditioning the reaction to powdery mildew were explained.

The pathogenic variability of the pathogen Erysiphe graminis DC. f. sp. hordei Em. Marchal which causes powdery mildew of barley has been studied extensively. Since Mains and Dietz (3) demonstrated the existence of physiologic races of this organism in North America about 30 years ago, additional races have been identified not only in North America, but in many other countries. Although many studies have shown the pathogenic variability of the fungus, the dynamics of this pathogenicity is not well understood.

The purpose of this study was to gain an insight into the dynamics of pathogenic strains of E. graminis f. sp. hordei which are now causing or may cause losses in the commercial production of barley in North America. Barley varieties were grown in nurseries in various areas of North America where powdery mildew is of economic importance. The reaction of the varieties to the pathogenic strains of the pathogen previously found in those areas was known. Some varieties susceptible to all the pathogenic strains previously isolated in North America were used as checks. Other varieties with known genes conditioning reaction were susceptible in some areas and resistant in others. Another group of varieties which have known genes conditioning reaction had been resistant in all previous tests with the pathogenic strains isolated in North America. The reactions of the varieties in these nurseries to the pathogen were observed. From each nursery leaves with cleistothecia were collected from those varieties which had been resistant to the pathogenic strains previously isolated from that area.

The technique used in obtaining cultures from cleistothecia was similar to those described by Moseman and Powers (6). The methods of inoculation and recording the reactions of plants

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[2]C.I. refers to the accession number of the Cereal Crops Research Branch, Crops Research Division.

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Table 1. Infection types on seedlings of 30 barley varieties inoculated with cultures of Erysiphe graminis hordei isolated from cleistothecia on plants grown in British Columbia, Canada, in 1951 and 1958 and in California.

Variety	C.I. Number	Infection type[a] with culture[b]						
		Calif. -CR3	Aga. 51 -BC3	Aga. 58 -Comp.	Aga. 58 -Type A	Aga. 58 -Type B	Aga. 58 -Type C	Aga. 58 -Type D
Black Hulless	666	4	3-4	4	4	4	4	4
Chevron	1111	2	1-2	1-2	1-2	1-2	1-2	1-2
Goldfoil	928	0-1	0	0	0	0	0	0
Heil's Hanna 3	682	4	4	4	4	4	4	4
Nepal	595	4	4	4	4	4	4	4
Peruvian	935	4	4	4	4	4	4	4
Kwan	1016	2	4	4	4	2	4	2
Rabat	4979	0	0	4	4	4	0	0
Algerian	1179	0	0-1	4	4	4	0	0
Marocaine 079	8334	0	0	4	4	4	0	0
Sel. 175	-	4	4	-	4	4	4	4
Hanna	906	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Psaknon	6305	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Ricardo	6306	0-1	0-1	1	0-1	1	1	1
Atlas	4118	4	4	4				
--	4974	3-4	3-4	4				
Batna	3391	4	-	4				
Duplex	2433	-	1	0-1				
Monte Cristo	1017	0-1	0-1	0-1				
Multan	3401	0	0-1	0				
Durani	6316	1-2	0-1	1-2				
Stephan	8051	0	1	0				
Modia	2483	1	0-1	1-2				
Hispont	8828	0	0-1	0				
Rupee	4355	0	0	0				
Mianwali	3400	1	0-1	0				
Long Glumes	6168	0	0-1	0-1				
Palmella Blue	3609	1-2	1	1-2				
Vagabond	3933	0	1	0-1				
Menelik	5862	0-1	1	0-1				

[a]The infection types were read on a 0-4 scale: 0 = immune, 1 = highly resistant, 2 = moderately resistant, 3 = moderately susceptible, and 4 = very susceptible.
[b]The cultures were as follows: Calif-CR3 = from California race 3; Aga. 51-BC3 = from Agassiz, British Columbia 1951 race 3; Aga. 58-comp. = from Agassiz, British Columbia 1958 composite of 6 collections; Aga. 58-types A, B, C, and D = from Agassiz, British Columbia 1958 representing different pathogenic types isolated.

to infection were similar to those published in 1956 (5).

Infection types on seedlings of 30 barley varieties inoculated with cultures of Erysiphe graminis f. sp. hordei isolated from cleistothecia on plants grown at Agassiz, B. C., Canada and California are given in Table 1. The cultures used were CR3, which had been used in previous studies (7, 10), culture Aga. 51-BC3, a typical culture isolated from cleistothecia on plants grown at Agassiz in 1951 (8), four pathogenically different types of cultures isolated in 1958, and a composite of these four cultures.

The first six varieties in Table 1 are the six standard varieties used in North America to differentiate races of powdery mildew. Their reaction is the same to infection with the cultures which are classified as physiologic race 3. The moderately resistant reaction of the variety Kwan (C.I. 1016) to cultures Aga. 58-types B and D is similar to the reaction to culture CR3. The susceptible reaction of Kwan to cultures Aga. 58-types A and C is similar to that to culture

Table 2. Infection types on seedlings of 30 barley varieties inoculated with cultures of Erysiphe graminis hordei isolated from cleistothecia on plants grown in northeastern United States and Ontario, Canada, 1951-1958.

Variety	C.I. Number	Infection type[a] with culture[b]					
		Ont. 51 Race 8	Pa. 54 -21.1	N.Y. 56 -061	N.Y. 57 -Erie	O.A.C. 58 -Gold.	N.E. -Comp.
Black Hulless	666	4	1-4	1-4	4	4	1-4 & 4
Chevron	1111	3-4	4	4	4	4	4
Goldfoil	928	0	0-1	0	4	4	4
Heil's Hanna	682	4	4	4	4	4	4
Nepal	595	4	2	2	4	4	2 & 4
Peruvian	935	2	2	2	2	2	2
Ricardo	6306	1	0-1	4	0	4	4
Modia	2483	1	0	4	0	4	4
Stephan	8051	0-1	0	0	4	4	4
Hanna	906	4	4	4	4	4	4
Anoidium	7269	2-3	2	2	2	2	2
Sel. 175	-	-	1-2	1-2	1-2	1-2	1-2
Psaknon	6305	1-2	1-2	1-2	1-2	1-2	1-2
Rabat	4979	0-1	0	0	0	0	0
Algerian	1179	1	0	0	0	0	0-1
Duplex	2433	1-2	1-2	1-2	1-2	1-2	2
Hispont	8828	1	0	0	-	0	0
Atlas	4118	-	2	2	-	2	2
Kwan	1016	2	1	2	-	2	2
Monte Cristo	1017	1	0	0	-	1	0-1
Multan	3401	1	0	0	-	0-1	0-1
Durani	6316	1	1	1-2	-	1-2	1-2
H 204	8825	-	0	0	-	0	0
--	4974	0	0-1	1	-	0	1
Batna	3391	-	1	2	-	2	2
Mianwali	3400	1	1	1	-	1	1
Long Glumes	6168	0-1	0	0	-	0	0
Palmella Blue	3609	1	0	1	-	2	1-2
Vagabond	3933	0	0	0	-	0	0
Menelik	5862	1	1	0-1	-	2	1-2

[a]The infection types were read on a 0-4 scale: 0 = immune, 1 = highly resistant, 2 = moderately resistant, 3 = moderately susceptible, and 4 = very susceptible.
[b]The cultures were as follows: Ont. 51-race 8 = from Ontario 1951 race 8; Pa. 54-21.1 = from Pennsylvania 1954 race 9; N.Y. 56-061 = from New York 1956 race 9; N.Y. 57-Erie = from New York 1957 race 21; O.A.C. 58-Gold. = from Ontario Agricultural College 1958 race 21; N.E. Comp. = the 3 cultures N.Y. 56-061, N.Y. 57-Erie, O.A.C. -58-Gold, and all cultures in Table 3.

Aga. 51-BC3 as reported by Atkinson (1), and Moseman and Starling (8). The varieties Rabat (C.I. 4979), Algerian (C.I. 1179), and Marocaine 079 (C.I. 8334) were susceptible to cultures Aga. 58-types A and B and immune from to highly resistant to all other cultures. The reactions of all the other 20 varieties to infection with the 6 cultures and the composite of cultures from 1958 were similar.

Infection types on seedlings of 30 barley varieties inoculated with cultures of Erysiphe graminis f. sp. hordei isolated from cleistothecia on plants grown in northeastern United States and Ontario, Canada from 1951 through 1958 are given in Table 2. The cultures used were Ont. 51-race 8 and Pa. 54-21.1, typical cultures of races 8 and 9 previously found in that area, three pathogenically different cultures isolated from cleistothecia on plants grown in 1956, 1957, and 1958, and a composite of eight cultures isolated from cleistothecia on plants grown

in Ontario, Michigan, Pennsylvania, and West Virginia in 1958. Culture N.Y. 56-061 isolated from cleistothecia on plants grown in 1956 is similar in pathogenicity to culture Pa. 54-21.1 except that varieties Ricardo (C.I. 6306) and Modia (C.I. 2483) are susceptible to culture N.Y. 56-061 and immune from to highly resistant to culture Pa. 54-21.1. Culture N.Y. 57-Erie isolated from cleistothecia on plants grown in 1957 is similar in pathogenicity to culture Ont. 51-race 8 except that varieties Goldfoil (C.I. 928) and Stephan (C.I. 8051) are susceptible to culture N.Y.57-Erie but are immune from to highly resistant to culture Ont. 51-race 8. Since Goldfoil is one of the six standard varieties used in differentiating races of powdery mildew in North America, culture N.Y. 57-Erie is not race 8 but a new race not previously reported to occur in nature in North America and is designated race 21. Culture O.A.C. 58-Gold. isolated from cleistothecia on plants grown at Guelph, Ontario in 1958 has the combined virulence of cultures N.Y. 56-061 and N.Y. 57-Erie and is virulent on the four varieties Ricardo, Modia, Goldfoil, and Stephan. Since the pathogenicity of culture O.A.C. 58-Gold. on the six varieties used as standard differentials in North America is similar to that of culture N.Y. 57-Erie, it also is designated as race 21. The reaction of each of the other 21 varieties to all the cultures was the same.

The pathogenic variation of cultures of powdery mildew isolated from cleistothecia on plants grown in Michigan, West Virginia, and Pennsylvania, and Ontario, Canada in 1958 is given in Table 3. Previous studies (2, 5, 9) had shown that race 8 (virulent on varieties Black Hulless and Nepal) and race 9 (avirulent on varieties Black Hulless and Nepal) were the predominant races in this area. Therefore, it could be anticipated that cultures varying in pathogenicity on the two varieties Black Hulless and Nepal would be obtained. The results given in Table 3 indicate the strains of the fungus present in that area vary in pathogenicity on those two varieties.

Table 3. Infection types on seedlings of 16 barley varieties inoculated with six cultures of Erysiphe graminis hordei from cleistothecia on plants grown in northeastern United States and Ontario, Canada, in 1958.

Variety	C.I. Number	Infection type[a] with culture[b]					
		Mich. -2483	Mich. -6306	O.A.C. -2483	O.A.C. -6306	Pa. -Erie	W. Va. -2483
Black Hulless	666	1-4	1-4	4	1-4	1-4	1-4
Chevron	1111	4	4	4	4	4	4
Goldfoil	928	0	0	4	0	4	0
Heil's Hanna 3	682	4	4	4	4	4	4
Nepal	595	4	2	4	2	2	4
Peruvian	935	2	2	2	2	2	2
Ricardo	6306	4	4	4	4	4	4
Modia	2483	4	4	4	4	4	4
Stephan	8051	0	0	4	0	4	0
Hanna	906	4	4	4	4	4	4
Anoidium	7269	2	2	2	2	2	2
Sel. 175	-	1-2	1-2	1-2	1-2	1-2	1-2
Psaknon	6305	1-2	1-2	1-2	1-2	1-2	1-2
Rabat	4979	0	0	0	0	0	0
Algerian	1179	0	0	0	0	0	0
Duplex	2433	1-2	1-2	1-2	1-2	1-2	1-2
Physiologic Race		14	9	21	9	12	14

[a]The infection types were read on a 0-4 scale: 0 = immune, 1 = highly resistant, 2 = moderately resistant, 3 = moderately susceptible, and 4 = very susceptible.

[b]The cultures were as follows: Mich.-2483 and Mich.-6306 = from Michigan varieties C.I. 2483 and C.I. 6306, respectively; O.A.C. -2483 and O.A.C. -6306 = from Ontario Agricultural College varieties C.I. 2483 and C.I. 6306, respectively; Pa.-Erie = from Pennsylvania variety Erie; W. Va.-2483 = from West Virginia variety C.I. 2483.

DISCUSSION AND CONCLUSIONS

Some of the variation in pathogenicity between cultures previously isolated at Agassiz, B. C. and those isolated in 1958 was expected. The variety Rabat was used as a source of resistance to powdery mildew by D. K. Taylor in the breeding program at Agassiz. In 1955 and 1956 some families with Rabat as their source of resistance to powdery mildew were found to be susceptible to a new pathogenic strain of the fungus in that nursery. Most of the plants in the nursery were resistant to the strains previously present, therefore, the selection pressure greatly favored this new strain. Since the varieties Rabat, Algerian, and Marocaine 079 have been resistant to all the cultures of the pathogen in North America with which they have been inoculated, the similarity in the reaction of those varieties to infection with these cultures may be important. The fact that they are resistant or susceptible to the same cultures indicates that they may have the same gene conditioning reaction to those cultures.

The change in pathogenic strains of powdery mildew in northeastern United States and Ontario, Canada indicates that selection pressure may be responsible in adapting the pathogen to the new sources of resistance in the host. The strains pathogenic on Ricardo and Modia may have been present but undetected previously because those two varieties had not been tested extensively. Since Goldfoil is the source of resistance in the commercial variety Erie, the most widely grown commercial spring variety in New York, strains virulent on Goldfoil may have been anticipated. Strains of the pathogen virulent on Stephan may also have been expected because this variety has been used for several years as a source of resistance to powdery mildew in the breeding program at the Ontario Agricultural College. There is some evidence that the same gene may condition the reaction in Goldfoil and Stephan. It has been found that the genes conditioning the reaction in these two varieties are not linked with the genes Ml_p, Ml_k, Ml_h, and ml_d (2, 10) and the varieties have the same reaction when inoculated with cultures of several races of the fungus (4).

The six standard varieties used to differentiate physiologic races of Erysiphe graminis f. sp. hordei in North America were found to be inadequate for identifying the total variation in pathogenicity of the new strains of the pathogen. The new pathogenic characteristics of the pathogen occurring either in British Columbia, Canada, or northeastern United States, and Ontario, Canada could not be detected with those six varieties. Only by including one of the varieties Rabat, Algerian or Marocaine 079 could the new strains in British Columbia be detected. The varieties Ricardo or Modia were necessary for identifying the new strains in northeastern United States and Ontario, Canada.

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PHYSIOLOGIC RACES OF CROWN RUST OF OATS IDENTIFIED IN 1958[1]

M. D. Simons and L. J. Michel[2]

DESCRIPTIONS OF NEW RACES

Since compilation of previously unnumbered races of crown rust (Puccinia coronata Cda. var. avenae Fraser & Led.) was made for 1957[3], two new races have been discovered. Reactions of the 10 standard differential oat varieties are shown in Table 1.

Table 1. Reactions of standard crown rust differential oat varieties to two races of crown rust.

Race Number	Anthony	Victoria	Appler	Bond	Land-hafer	Santa Fe	Ukraine	Tri-spernia	Bondvic	Saia
298	S	R	R	S	S	R	R	R	R	R
299	S	S	R	R	R	R	S	R	R	R

Race 298 was isolated first from crown rust collected on Minhafer oats near Ames, Iowa. So far as the authors know, this is the first race of crown rust capable of parasitizing Landhafer but not Santa Fe reported in North America. Such races are known in South America, but these differ from race 298 in their pathogenicity on other varieties. Landhafer is moderately susceptible to race 298, while Santa Fe exhibits heavy flecking, some of the flecks containing small pustules. The Landhafer derivative Minhafer appeared to be highly susceptible when used to increase inoculum of this race. Only very young leaf tissue of Anthony is susceptible to race 298, and this variety appeared to be intermediate or resistant in some tests. In all tests Trispernia was highly resistant, while Bondvic was only moderately resistant and sometimes was even intermediate in reaction. Race 298 differs sharply from all members of race group 290 and all other races common at present in inducing a highly resistant reaction in the usually susceptible Appler variety. Certain key supplementary differentials, however, react similarly to race 298 and races of race group 290.

Race 299 was isolated from a collection of crown rust made in Minnesota. It appears to be a "good" race in that the differential varieties show clear-cut resistant or susceptible reactions but has little significance for plant breeding.

PREVALENCE AND DISTRIBUTION OF RACES IN 1958

Over the country as a whole, crown rust was rather light in 1958. Less than half as many uredial collections were received as in the severe crown rust year 1957. These collections were made from Uniform Oat Rust Nurseries, other breeding and disease nurseries, and commercial fields well-distributed through the principal oat-growing regions of the United States. Five-hundred-ninety-one isolates from this material were identified (Table 2).

The overall pattern of relative prevalence of the more common races and race groups was much the same as that in 1957. Races attacking Victoria comprised 71 percent of the total. Race 216 alone accounted for 54 percent, as compared with 42 percent in 1957. The standard differential oat varieties Anthony, Victoria, Appler, Bond, and Ukraine are parasitized by race 216. Under greenhouse conditions Trispernia and Bondvic are moderately resistant and Landhafer, Santa Fe, and Saia are highly resistant. Under some conditions in the field, however, Landhafer varieties may appear to be damaged somewhat by race 216. The second most common race, race 213, also attacks Victoria but does not attack Ukraine. It comprised 14

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[2]Pathologist and Agricultural Aid, respectively, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

[3]Simons, M. D., and L. J. Michel. 1958. Physiologic races of crown rust of oats identified in 1957. Plant Disease Reptr. 42: 1246-1249.

Table 2. Prevalence and distribution of physiologic races of P. coronata avenae isolated from susceptible and differential varieties of oats grown in North America in 1958.

State or country	Number of isolates of indicated race																				Totals	
	202	203	205	212	213	216	226	235	237	258	264	274	279	284	290	293	294	295	298	299	Isolates	Races
Ala.						2															2	1
Calif.	1					1															2	2
Fla.	1	1			1						3		1		7	5					19	7
Ga.					1	17					2										20	3
Ill.					2	3									2			2			9	4
Ind.		1			1	4							1					1			8	5
Iowa	9	1	1		15	49									7	3	2	4	1		92	10
Kans.	3	1		1	10	24					1										40	6
Ky.	1																				1	1
Mexico					1	1															2	2
Mich.						26					1										27	2
Minn.	11	5			17	23					2				2	1			1	1	63	9
Miss.	2				1	5		1			1		1								11	6
Mo.	7	9			4	40															80	4
Nebr.	6	2			4	16															28	4
N. Y.						2						1		1							4	3
N. Car.	2				2																4	2
N. Dak.	4					8			1						1						14	4
Ohio		1															1	2			4	3
Pa.	10					1															11	2
S. Car.					1	2															3	2
S. Dak.	1				1	9					1	1									13	5
Tex.	6	3			18	66							1								94	5
Va.	4	2		1		14	1		8	1					2	1			1		35	10
Wis.	7	3			3	5					1				4			2			25	7
Total isolates	75	29	1	2	82	318	1	1	9	1	12	2	4	1	25	10	3	11	3	1	591	
Percent of total	13	4.9	.2	.3	14	54	.2	.2	1.5	.2	2.0	.3	.7	.2	4.2	1.7	.5	1.9	.5	.2		
Total States and countries	16	11	1	2	16	21	1	1	2	1	8	2	4	1	7	4	2	5	3	1		

percent of the total.

The next most common group of races included those attacking Bond but not Victoria or Landhafer. These made up 18 percent of the total. The most prevalent of these races was race 202, which, prior to 1957, had been identified more often than any other race. Race 202 comprised 13 percent of the total in 1958. Most of the Victoria and Landhafer races also attack Bond. Consequently, Bond was susceptible to most isolates identified.

As in 1957, races attacking Landhafer were isolated from oats growing in States widely scattered over the country. Eleven percent of all isolates identified fell in this group. Because of the disproportionate number of crown rust collections made from resistant varieties, this figure is probably considerably higher than the actual prevalence of these races in the field. The Landhafer races did not appear to be any more common in 1958 than they had been in 1957. Race 264, which attacks all the differential varieties except the diploid Saia, made up 2 percent of the total isolates. Races of race group 290 (races 290, 293, 294, 295, and 298), which attack Landhafer but not Victoria, Trispernia, or Bondvic, made up 9 percent of the total.

One-hundred-forty-one isolates originating as aecial collections from the alternate host were identified (Table 3). The aecial collections showed a distinctly different pattern of relative racial prevalence from the uredial collections. Races attacking Bond but not Victoria were the most common. Races attacking Victoria were in second place. Race 264 was not identified from this material, but races of race group 290 were probably about as common as in the uredial collections.

Table 3. Prevalence and distribution of physiologic races of P. coronata avenae isolated from Rhamnus spp. in 1958.

State	Number of isolates of indicated race													Totals	
	202	203	205	212	213	216	237	240	258	280	284	290	295	Isolates	Races
Ill.	10	3		1	1	2						3	3	23	7
Iowa	25	7	1	3	15	9		1				1		62	8
Minn.		1				3								4	2
Nebr.	2				1									3	2
N. Y.						1								1	1
Pa.	1	1												2	2
S. Dak.	18	5		1	6	5	2	2	1	1	1			42	10
Wis.	1	1										2		4	3
Total isolates	57	18	1	5	23	20	2	3	1	1	1	6	3	141	
Percent of total	40	13	.7	3.5	16	14	1.4	2.1	.7	.7	.7	4.3	2.1		
Total States	6	6	1	3	4	5	1	2	1	1	1	3	1		

The relatively greater prevalence of the Bond races may possibly be explained by the fact that they produce telia more readily and in greater abundance on commonly grown oat varieties than the Victoria races 213 and 216. The present-day Victoria races, however, unhampered by telial formation, produce larger quantities of urediospores than do the Bond races. Even where development of telia is not a factor, the Victoria races have been observed to increase at the expense of other races. Consequently, the cycle of events may be something as follows. The majority of the telia overwintering in the northern States are Bond races, and these give rise mainly to Bond races on the alternate hosts. Some Victoria-attacking crown rust, however, also overwinters or arises from genetic recombination on the alternate host. Once on the oats this material increases more rapidly than the Bond races. Inoculum originating in southern States, where the fungus overwinters in the uredial stage, would add further to the preponderance of the Victoria races, so that by late in the season, when most uredial crown rust collections are made, the Victoria races make up the majority of the collections.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND IOWA AGRICULTURAL AND HOME ECONOMICS EXPERIMENT STATION, AMES

FUSARIUM GRAMINEARUM AND OTHER FUNGI IN SEEDSTOCKS OF SMALL GRAINS[1]

W. F. Crosier and E. C. Waters[2]

Abstract

Favored by cool, humid weather in 1958, Fusarium spp., especially F. graminearum, infected many of the small grain seedstocks produced in New York State. The scab fungi were present in 28, 23, 41, and 65 percent respectively of well-cleaned, untreated samples of barley, oats, rye, and wheat examined at the State Seed Laboratory. These percentages exceeded those of any other year since 1943 with the exception of barley in 1947 and 1957 and of oats in 1947, 1949, and 1952. Oat seedstocks carrying Epicoccum spp. were also of record magnitude in 1958. The percentages of fungus-seed associations did not indicate significant varietal differences in barley, oats, and wheat to Epicoccum spp. or Fusarium spp.

INTRODUCTION

Head blight of small grains caused by the scab fungus Fusarium graminearum Schwabe was widespread in New York State in 1957 and 1958. The cool, humid weather especially in June and July favored development of this and other species of seed-inhabiting fungi. Similar environal conditions existed in some of the out-of-State areas from which seedstocks were procured for local planting. Ullstrup and Laviolette[3], for example, reported that a disease-favoring environment was common throughout northern Indiana in 1958. Southern Ontario, a producing area for wheat seedstocks also experienced above average rainfall and below normal temperatures in 1958.

As reported previously by Crosier and Waters[4], Alternaria tenuis, auct., Epicoccum spp., and Fusarium spp. were present in 100, 20, and 20 percent respectively of the oat seedstocks examined during the winter of 1957-58. Approximately the same rates of fungus-seed associations were recorded for several hundred 1958 and 1959 crop seedstocks received since the earlier report.

The percentages of 1958 crop seedstocks carrying scabby kernels were even higher for the winter grains -- barley, rye, and wheat -- and for spring barley than for oats. This led to the opinion that changes in varieties and/or in processing methods as well as the favorable weather may have contributed to the heaviest scab infection ever recorded in New York State. To test this opinion and the conclusion, the individual records of fungus-seed associations for the last 15 years were tabulated for presentation in this paper.

MATERIALS AND METHODS

Since 1943 all samples of small grains received at this experiment station for analytical and germination testing have also been examined for seed-borne fungi. The samples were taken from seedstocks intended for planting in the State and were mostly produced within the State. Since 1951, however, an annually increasing percentage of the oat seedstocks -- about 15 percent in 1958 -- were of out-of-State origin. The wheat samples were of in-State production until 1957 and since then of both New York and Ontario production.

Neither Fusarium graminearum nor other fungi were readily observed on dry seeds. During germination, however, the seeds were discolored by the mycelia of Alternaria tenuis, Curvularia inaequalis, Epicoccum spp., Fusarium spp., Helminthosporium spp., and Hormo-

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[1] Approved by the Director for publication as Journal Paper No. 1172.

[2] Seed Pathologist (currently serving as Consultant to the Virginia State Department of Agriculture and Immigration) and Seed Technologist, respectively.

[3] Ullstrup, A. J., and F. A. Laviolette. 1959. Diseases of corn and of sorghum species in Indiana in 1958. Plant Disease Reptr. 43:334-336.

[4] Crosier, W. F., and E. C. Waters. 1959. Septoria avenae and other fungi in, and chemical treatment of, oat seeds. Oat Newsletter 9:11-14.

Table 1. Incidence of Fusarium spp. in germinating samples of small grains.

Year grown	Seed treated	Percent of samples infected with Fusarium spp.			
		Barley	Oats	Rye	Wheat
1944	In part	--	--	--	11
1945	In part	1	--	--	--
1946	In part	Tr	--	--	5
1947	In part	28	24	--	40
1948	In part	15	9	--	42
1949	In part	Tr	26	--	1
1950	In part	--	15	28	25
1951	No	15	8	27	16
1951	Yes	17	3	--	12
1952	No	10	24	26	11
1952	Yes	7	6	--	8
1953	No	24	4	8	9
1953	Yes	4	Tr	6	6
1954	No	21	5	6	6
1954	Yes	5	1	--	4
1955	No	9	6	3	4
1955	Yes	2	2	--	2
1956	No	27	19	16	15
1956	Yes	8	6	--	7
1957	No	34	9	24	28
1957	Yes	1	3	--	36
1958	No	28	23	41	65
1958	Yes	4	10	--	22

Table 2. Samples carrying Epicoccum spp. and Fusarium spp. in untreated seed of certain varieties of small grains.

Year grown	Variety or group	Epicoccum spp. (percent)	Fusarium spp. (percent)
	BARLEY		
1958	Erie	6	35
1958	Hudson	4	22
1958	Wong	5	27
	OATS		
1949	Bond derivatives	--	34
1949	Other varieties	--	5
1954	Bond derivatives	25	4
1954	Craig	44	2
1954	Other varieties	32	15
1957	Bond derivatives	27	6
1957	Garry, Rodney	35	11
1957	Other varieties	28	7
1958	Bond derivatives	68	43
1958	Garry, Rodney	81	22
1958	Other varieties	42	19
	WHEAT		
1951	Thorne	5	44
1951	White-seeded	2	15
1958	Cornell 595	6	42
1958	Genesee	7	68

dendron cladosporioides. Species of Fusarium and Helminthosporium also discolored or killed seedlings if the germination testing was continued to a 10-day period.

Internally-borne fungi including species of Acremoniella, Cladosporium, Diplodia, Rhizoctonia, and Stemphylium, in addition to those named above, were regularly determined for wheat, occasionally for the other kinds. The seeds were surface sterilized in sodium hypochlorite, transferred to plates of malt-dextrose, potato-dextrose or Sabouraud's agar and incubated for 10 days at 21° C.

RESULTS AND DISCUSSION

The percentages of Fusarium-infected samples were greater for the 1958 crops of rye and wheat than for any previous ones. When both mercury-treated and untreated samples were considered, the percentages of infested wheat of the 1947 and 1948 crops actually exceeded those of 1958. On the basis of untreated seed alone, however, the 65 percent for 1958-crop wheat (Table 1) slightly exceeded similar values for untreated seed of the earlier crops.

The planned application of a formulation containing a mercurial or thiram to untreated seeds has inhibited the growth of Fusarium spp., controlled seedling infection and frequently reduced the percent of visually infected seeds, but has only rarely prevented all development of these fungi. Nevertheless, treatment did reduce the percentage of samples in which seeds carried mycelium of Fusarium spp. capable of demonstrating growth in 10 days at 21° C (Table 1). There were exceptions to this result, as in 1957 when the growths of Fusarium spp. were observed in a greater percentage of treated than of untreated samples.

Susceptibility to head blight seemed not to differ materially for the several varieties of barley, oats, and wheat grown in this State. A high percentage of seedstocks of the two varieties of soft white winter wheat carried scabby kernels (Table 2). Of the 1951 crop, the Thorne variety was more commonly infected than the white-seeded varieties, probably because the former was grown in a more humid area than the latter ones.

By 1954 Epicoccum purpurascens and E. neglectum were evident on many samples of germinating oats. These fungi as well as Fusarium spp. have been seed-borne in every variety of oats tested at this station. Epicoccum spp. were more prevalent than Fusarium spp. on seedstocks of all varieties, and especially on those of Garry and Rodney.

Table 3. Glume-discoloring fungi observed in germinating samples of oats.

Year grown	Percent of samples containing seeds carrying:			
	Alternaria tenuis		Epicoccum spp.	
	Not treated	Treated	Not treated	Treated
1955	93	1	43	Tr
1956	88	Tr	22	1
1957	89	Tr	39	1
1958	91	1	73	4

The glume-discoloring fungi, Alternaria tenuis and Epicoccum spp., were controlled by various formulations of mercurials. The former fungus was more sensitive than the latter to mercury (Table 3). This statement is especially significant when total seeds are considered. In germination tests the discoloration by Alternaria tenuis averaged 83 seeds per 100 in 1958. Mercurial treatment reduced the discoloration to an average of 0.03 percent. Similar values for pink mold by Epicoccum spp. were 2.19 and 0.08 percent.

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TREATMENT OF FORAGE LEGUME SEEDS WITH FUNGICIDES IN THE SOUTH[1]

Howard W. Johnson[2]

Summary

Stands obtained when treated and untreated seeds of Dixie crimson clover, Kenland red clover, Hubam sweetclover, and Buffalo alfalfa were planted in the field at three locations in the South are presented. Treatment increased seedling stand of crimson and red clover significantly only in one test at Stoneville, Mississippi. No significant improvement in stand was obtained at any location from planting fungicide-treated seeds of sweetclover and alfalfa.

When seeds were planted at Stoneville after a storage period of 14 months, significant improvements in stand were obtained with seeds of Dixie crimson clover treated with Arasan, Spergon, or Vancide 51 ZW, with Spergon-treated seeds of Kenland red clover, and with Spergon-treated seeds of Buffalo alfalfa. Germinability was not increased when treated seeds were stored 26 months before planting.

No significant differences in yield of hay were obtained over a 3-year period when untreated and Arasan- or Spergon-treated seeds of 10 alfalfa varieties were planted in plots at Stoneville.

INTRODUCTION

Since most studies of fungicide-treated forage legume seeds were at northern locations, work was initiated the fall of 1952 to determine the results that would be obtained in the South from similarly treated seeds. Data were obtained from plantings made during 1952-55. Alfalfa hay yields from fungicide-treated seeds and soil were reported earlier[3].

MATERIALS AND METHODS

Seeds of Dixie crimson clover, Kenland red clover, and Hubam sweetclover were treated with Arasan (50% tetra-methylthiuram-disulfide) and Spergon (96% tetrachloro-para-benzoquinone) at 8 ounces/100 pounds of seed. Treated and untreated seeds were sown 100 seeds per 10-foot row and replicated five times in randomized split-plot blocks at State College, Mississippi, on October 30, 1952. Similar plantings were made at Beaumont, Texas on September 28, 1953 and at Stoneville, Mississippi on October 2 and 16, 1953. Buffalo alfalfa was included in the 1953 tests. An additional fungicide, Vancide 51 ZW (70% ziram and zinc salt of 2-mercaptobenzothiazole), was included in 1953, at 8 ounces/100 pounds of seed. Stand counts were made about 4 weeks after seeding at Beaumont and about 6 weeks after seeding at State College and Stoneville.

Fungicide-treated and untreated seeds remaining from the 1953 seedings were stored in cloth bags at 60° F at Stoneville. Viability of the stored seeds was determined by sowing 14- and 26-month-old samples in field soil and counting the seedling stands.

Seeds of 10 varieties of alfalfa were treated with Arasan or Spergon at 8 ounces/100 pounds and sown in 6- x 20-foot plots at Stoneville on October 25, 1952. The varieties included were: Argentine, Atlantic, Buffalo, Caliverde, Du Puits, Kansas Common, Narragansett, Oklahoma Common, Uruguay Clone 10, and Williamsburg. The planting was replicated three times in

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[1] A report of cooperative work conducted by the Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and the Mississippi Agricultural Experiment Station.

[2] Research Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and the Mississippi Agricultural Experiment Station. The writer is indebted to Ralph M. Weihing for planting the test and making the stand counts at Beaumont, Texas.

[3] Johnson, H. W. 1957. Effect of seed and soil treatments on alfalfa hay yields. (Abst.) Phytopathology 47: 18.

randomized split-plot blocks, with alfalfa varieties as main plots and treatments as subplots. Untreated seeds of each variety were planted as controls. A visually uniform stand developed in all plots. No hay yields were obtained in 1953; however, three harvests of hay per year were weighed during 1954-56. Hay yields were determined by cutting a swath 3 x 14 1/2 feet in each subplot. Green weight was recorded at harvest. Dry weight and percentage dry matter were determined from oven-dried samples.

Data concerning seedling stands and hay yields were analyzed statistically by the analysis of variance.

RESULTS AND CONCLUSIONS

The percentage stands obtained when treated and untreated seeds of forage legumes were planted in rows in the field at three locations in the South are summarized in Table 1. Signi-

Table 1. Stands obtained when treated and untreated seeds of forage legumes were planted in rows in the field at three locations in the South.

Legume	Where planted[b]	Percentage stand[a]			
		Arasan[c]	Spergon[c]	Vancide 51 ZW[c]	Untreated
Crimson clover, var. Dixie	State College	54	52		51
	Stoneville, A	49*	52*	47	42
	Stoneville, B	51	49	50	48
	Beaumont	62	68	67	72
Red Clover, var. Kenland	State College	34	35		37
	Stoneville, A	21	20	25*	15
	Stoneville, B	22	21	23	23
	Beaumont	55	53	53	56
Sweetclover, var. Hubam	State College	29	26		25
	Stoneville, A	16	17	14	14
	Stoneville, B	18	17	15	12
	Beaumont	28	26	20	22
Alfalfa, var. Buffalo	Stoneville, A	42	49	46	44
	Stoneville, B	48	47	42	45
	Beaumont	55	70	64	67

[a] Each figure is the mean of five replicates planted 100 seeds per 10-foot row.

[b] Planting dates were Oct. 30, 1952, at State College, Miss.; Oct. 2 (A) and 16 (B), 1953, at Stoneville, Miss.; and Sept. 28, 1953, at Beaumont, Texas.

[c] At rate of 8 ounces/100 pounds of seed.

* Asterisks mark the means significantly higher than the mean of untreated seed. (LSD at 5% level = 6.7)

ficant increases in stand of Dixie crimson clover were obtained from seeds treated with Arasan or Spergon in a planting made at Stoneville on October 2, 1953. The stand of Kenland red clover was increased significantly by treating the seeds with Vancide 51 ZW in the same test. No significant improvement in stand was obtained at any location from planting fungicide-treated seeds of Hubam sweetclover and Buffalo alfalfa.

When treated and untreated seeds of Dixie crimson clover, Kenland red clover, Hubam sweetclover, and Buffalo alfalfa were stored for about 14 months and then planted in field rows at Stoneville, significant increases in stand were obtained from seeds of Dixie crimson clover treated with Arasan, Spergon, or Vancide 51 ZW. The respective percentage stands were 43, 45, and 47 compared with 35 percent for untreated seeds. The increase in stand obtained from Spergon-treated seeds of Kenland red clover was similar: 46 percent, compared with 36 percent for untreated seeds. Spergon-treated seeds of Buffalo alfalfa also gave a significantly better stand than did untreated seeds: 43 percent, compared with 34 percent. Stored Hubam sweetclover seeds showed no benefit from any of the treatments. When treated seed were stored 26

months before planting, no stand improvement was obtained with any of the four legumes.

Hay yields obtained during a 3-year period from plots established with treated and untreated seeds of 10 alfalfa varieties at Stoneville are summarized in Table 2. Differences between treatments were not statistically significant in any of the 3 years. Differences among alfalfa varieties were not significant in 1954, but were significant in 1955 and 1956. These results show that the alfalfa varieties began to differ in yield as the stand aged.

Table 2. Mean yields of moisture-free hay obtained from plots planted with treated and untreated seeds of 10 alfalfa varieties at Stoneville, Mississippi[a].

Treatment[b]	Yield of moisture-free hay[c] (tons/acre)			
	1954	1955	1956	Mean
Arasan	4.01	3.63	3.40	3.68
Spergon	4.05	3.62	3.36	3.67
None	3.93	3.55	3.37	3.62

a The alfalfa varieties included were Argentine, Atlantic, Buffalo, Caliverde, Du Puits, Kansas Common, Narragansett, Oklahoma Common, Uruguay Clone 10, and Williamsburg.

b Rate was 8 ounces/100 pounds.

c Each figure is the mean total production for three cuttings of each variety each year from three replicates. The differences are not significant by statistical test.

Because of the preponderance of negative results in the field tests reported herein, the writer cannot recommend treating seeds of forage legumes with fungicides as a general practice in the South. In special situations, such as planting in a field known to be infested with damping-off fungi, seed treatment is recommended. Under such conditions, the use of treated seed may mean the difference between failure and a satisfactory stand.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE,
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THE EFFECTS OF APPLICATIONS OF MICRO-NUTRIENTS TO ARIZONA FIELD-GROWN LETTUCE[1]

Robert B. Marlatt[2]

Abstract

Calcium, magnesium, iron, manganese, cobalt and zinc were applied to field-grown lettuce as aqueous sprays, soil applications or both. Experimental plots were randomized and replicated and all results were evaluated by use of analysis of variance and Duncan's multiple-range test.

Head weights were reduced by soil applications of 1000 pounds per acre of calcium oxide and by 200 pounds per acre of calcium ethylenediamine tetraacetic acid (EDTA). Foliar sprays of 4.8 grams of magnesium sulfate in 2 gallons of water weekly after thinning significantly decreased rib-discoloration disease. Magnesium EDTA, 10 and 50 pounds per acre, increased head weights significantly. Iron EDTA sprays containing 2 pounds per 100 gallons burned lettuce heads. Manganese EDTA, 2 pounds per 100 gallons, significantly reduced head size and rib discoloration. Applications of 1000 ppm cobalt chloride also decreased rib discoloration significantly. Early yields were significantly increased by weekly sprays containing 323 or 969 ppm zinc sulfate or 1650 ppm zineb (zinc ethylenebis dithiocarbamate). A side dress of 100 pounds zinc sulfate per acre also significantly increased early yields. Some plants were killed by weekly sprays of zinc EDTA, 4 pounds per 100 gallons and yields reduced by 2 pounds per 100 gallons. Side dressing with zinc EDTA at 200 pounds or zinc sulfate at 1000 pounds per acre also reduced lettuce stands.

INTRODUCTION

During studies of the cause and control of two lettuce diseases, six micro-nutrients were applied to the soil or as foliage sprays on field-grown lettuce. The effects of the micro-nutrients on disease incidence or severity were recorded as well as indications of phytotoxicity and effects on yields.

MATERIALS AND METHODS

Calcium, magnesium, iron, manganese and cobalt were applied to lettuce on the University of Arizona Mesa Farm to note any effects they might have upon rib discoloration (6), the cause of the disease being unknown.

In 1956, aqueous micro-nutrient sprays were applied weekly to lettuce, beginning at the seedling stage. A plot consisted of a two-row, raised bed 20 feet long. Plots were randomized and replicated seven times in a Latin square design. Solutions of the following materials were used to thoroughly wet the plants: cobalt chloride -- 10, 100 and 1000 ppm; iron ethylenediamine tetraacetate (EDTA)[3] -- 2 pounds per 100 gallons; manganese EDTA[4] -- 2 pounds per 100 gallons; magnesium EDTA[5] -- 4 pounds per 100 gallons; controls which were not sprayed.

A similarly designed experiment was performed in 1957 using weekly aqueous sprays of cobalt sulfate -- 1000 ppm, manganese EDTA -- 1 pound per 100 gallons, manganese sulfate -- 3.35 grams in 2 gallons to provide manganese equivalent to the manganese EDTA. Also used were sprays of magnesium EDTA -- 1 pound per 100 gallons, magnesium sulfate -- 4.81 grams in 2 gallons to provide magnesium equivalent to the magnesium EDTA, calcium chloride ($2H_2O$) -- 44.5 grams per 2 gallons and controls which were not sprayed.

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[1]Arizona Agricultural Experiment Station Technical Paper No. 499.

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[3]Sequestrene NaFe (12 percent Fe)

[4]Sequestrene Na_2Mn (12 percent Mn)

[5]Sequestrene Na_2Mg (5.5 percent Mg)

Materials used in 1958 for an experiment of similar design included calcium oxide (technical grade) -- 1000 pounds per acre and calcium EDTA[6] -- 200 pounds per acre, thoroughly mixed into the beds before planting and weekly aqueous sprays of magnesium sulfate at concentrations of 2, 4 and 8 grams per gallon. Two soil fumigants and controls were included in the 7 by 7 Latin square. In a companion experiment, the following technical-grade materials were thoroughly mixed in the soil before planting; magnesium sulfate -- 100 and 1000 pounds per acre, magnesium chloride -- 100 and 1000 pounds per acre and magnesium EDTA -- 10, 50 and 200 pounds per acre.

Zinc and calcium were applied to lettuce grown in fields with histories of big-vein disease (10). The 1955 experiment consisted of a 6 by 6 Latin square containing treatments on 50-foot lettuce beds. Treatments included 40 pounds per acre of zinc sulfate, side dressed before thinning, and weekly sprays of zinc sulfate containing 323 and 969 ppm, zinc ethylene bis dithiocarbamate (zineb) 1650 ppm to provide zinc equivalent to the more concentrated zinc sulfate spray and calcium chloride spray 1000 ppm. Control plots remained untreated.

In 1956 a 7 by 7 Latin square contained the following weekly spray treatments, each on 100 feet of bed; zinc sulfate -- 250 ppm, zinc EDTA[7] -- 2397 ppm, zineb -- 2397 ppm, calcium chloride -- 1000 ppm, two hormone sprays and an untreated control. The final, 1957, plots were 100 feet long and designed as a 9 by 9 Latin square. They contained soil applications of zinc sulfate -- 100 and 1000 pounds per acre, zinc EDTA -- 50 and 200 pounds per acre, weekly sprays of zinc sulfate -- 1 and 4 pounds per 100 gallons, zinc EDTA -- 4 pounds per 100 gallons, zineb -- 4 pounds per 100 gallons and controls which were not treated.

CALCIUM

Two calcium-deficiency diseases of vegetables have occasionally been seen in Arizona, celery blackheart (8) and tomato blossom-end rot (5). No severe calcium-deficiency symptoms of lettuce, such as rosette (20) or chlorosis, curling and necrosis of leaf tips (21) have been reported in the State. Elsewhere, lettuce responses to calcium applications have been obtained (1, 4, 13).

None of the three foliar sprays or two soil applications of calcium materials caused any obvious symptoms of phytotoxicity. Head weights, however, were significantly lighter in plots that had received 1000 pounds per acre of calcium oxide and those receiving 200 pounds per acre calcium EDTA. These differences were found in the 1958 experiment by orthogonal comparison of these two calcium treatments with the other six treatments combined.

MAGNESIUM

No report has been found of magnesium deficiency having been definitely demonstrated to occur in Arizona's commercial vegetable crops. A similarity has been found, however, between cantaloup deficiency symptoms and a type of injury occurring occasionally in field-grown melons (17). At times lettuce exhibits symptoms which have been ascribed to magnesium deficiency in other areas, chlorotic blotching of older leaves (2) and delayed heading (14). Lettuce has been found to take up magnesium applied to the soil (4).

Foliar sprays of magnesium EDTA, 4 pounds per 100 gallons, in 1956 and of magnesium sulfate, 4.8 grams in 2 gallons, in 1957 resulted in significantly less rib discoloration. Control of the blemish was not sufficient to be of economic importance. In 1958, orthogonal comparisons of magnesium EDTA, 10 and 50 pounds per acre, with the remaining treatments showed a significant increase in head weights as a result of the magnesium applications.

IRON AND MANGANESE

The iron (11) and manganese (12) contents of lettuce have been determined, as well as the observation and control of manganese deficiency symptoms (18). Manganese sulfate has been recommended as a spray to control a deficiency of the element in plants (15, 9).

Applications of iron and manganese as sprays did not benefit lettuce in two seasons' experiments. Iron EDTA at a concentration of 2 pounds per 100 gallons caused an unsightly brown to black spotting on the tops of sprayed heads. Although manganese sprays caused no discoloration of the leaves, sprayed heads were significantly smaller than those that had received other

[6]Sequestrene Na_2Ca (8.5 percent Ca)
[7]Sequestrene Na_2Zn (17.42 percent ZnO)

treatments in 1956. Perhaps because of this slight stunting, there was significantly less rib discoloration in lettuce sprayed with manganese EDTA, 2 pounds per 100 gallons. This decrease in severity was not sufficient to be of economic value.

COBALT

No descriptions of cobalt deficiency symptoms of vegetables or of responses to cobalt applications by field-grown plants were found. The element has been found, however, in lettuce tissues (3). Cobalt was applied to Arizona lettuce in an attempt to prevent the formation of brown rib-discoloration lesions. It has been shown that cobalt can depress peroxide formation (7) and others have suggested a peroxidative conversion of pyrogallol to purpurogallin, (19). It was theorized that if rib discoloration involves purpurogallin, applications of cobalt might prevent darkening of lesions, rendering them less conspicuous.

No phytotoxicity was noted in lettuce sprayed with cobalt at concentrations up to 1000 ppm of cobalt chloride. In 1956 there was significantly less rib discoloration in lettuce that had been sprayed with this concentration but enough of the disease was still evident to make the crop unmarketable.

ZINC

Lettuce big vein was reportedly controlled in Connecticut by zinc sulfate drenches prior to transplanting (16). During 3 years of experimentation in Arizona, foliar and soil applications of zinc materials have not given control. However, yields have been affected. In 1955, zinc sulfate sprays containing 323 and 969 ppm and the zineb spray of 1650 ppm significantly increased lettuce yields during the first harvest. Side dressing with 100 pounds of zinc sulfate per acre also increased the first harvest significantly in 1957.

Zinc EDTA applied as a foliar spray of 2 pounds commercial material per 100 gallons of water (2397 ppm) significantly reduced yields in 1956 and significantly decreased stands at a strength of 4 pounds per 100 gallons in 1957. When the same material was side dressed at a rate of 200 pounds per acre in 1957, stands were again significantly reduced. Similar phytotoxicity was caused by side dressing with 1000 pounds per acre of zinc sulfate. Many plants remained stunted throughout the season and this type of injury existed in addition to the loss of stand.

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THE EFFECTS OF GIBBERELLIN AND FUNGICIDES ON BEAN ROOT ROT[1]

Robert L. Rackham and John R. Vaughn[2]

Abstract

Several fungicides were tested alone and in combination with gibberellin in the greenhouse for control of bean root rot. No fungicidal treatments gave significant control of the disease; however, fungicides in combination with gibberellin resulted in highly significant root-rot control.

Fusarium solani f. phaseoli has been reported to be the most prevalent organism causing bean root rot in Wyoming (3, 4). The disease causes much concern to Wyoming bean growers. Although considerable information is available about the disease, there is still need for more effective control measures. In an attempt to fill this need, the use of fungicides alone and in combination with gibberellin was investigated (2).

Wittwer and Bukovac (5) suggested that gibberellin, a plant-growth substance, might be incorporated into seed protectants as slurries. They theorized that early emergence and rapid seedling growth might enable young plants to bypass insect and disease hazards.

METHODS AND MATERIALS

Two greenhouse screening trials for fungicides and gibberellin with fungicides were conducted using Fusarium solani f. phaseoli as the test organism and Great Northern beans as the host plant (Fig. 1a).

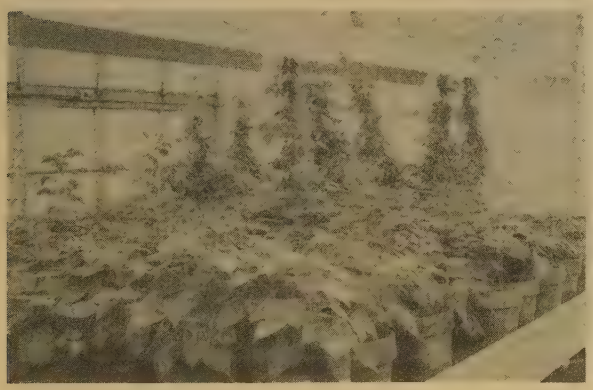

FIGURE 1a. General view of greenhouse bench showing the fungicide test in the foreground and the gibberellin treated plants in the background.

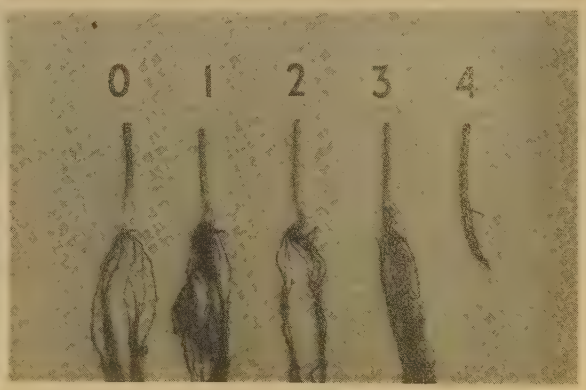

FIGURE 1b. Beans representing the relative amount of root rot for each disease rating.

Two isolates with a pathogenicity rating above three on a scale of zero to four were seeded on agar and allowed to increase in culture plates at room temperature for 8 days. A steam-sterilized sand and soil mixture contained in 6-inch pots was infested with a spore suspension of the pathogen in water. The pots were watered from the top to wash the organism throughout the soil and allowed to stand for 3 days before chemical treatment of the soil.

Diluted fungicides of known concentrations were stirred into the soil as a 100-ml drench. The pots were then filled with water for 2 days in an attempt to seal in the fungicides. Each pot

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of soil was planted with 10 Great Northern bean seeds and thinned to five plants per pot after germination in order to obtain a uniform number of plants for root-rot ratings. Each treatment was replicated three times and rated after 6 to 9 weeks for root rot.

The gibberellic acid was diluted in water according to the method outlined by Marth, Audia and Mitchell (1). One-half gm of gibberellic acid was completely dissolved into 2 ml of 95 percent ethyl alcohol. One-half ml of liquid detergent, which acts as a surfactant, was added to this gibberellin-alcohol mixture. This solution was added slowly with vigorous stirring to 1 liter of water which resulted in a 500 ppm solution used for making the lower concentrations.

The gibberellin solutions were sprayed in a fine mist to the point of runoff onto the bean foliage at primary leaf stage of growth with a small hand sprayer. Applications were made within a clear-plastic bag placed around the plants and pot which prevented the spray drift of the growth stimulator to other beans in the series.

EXPERIMENTAL RESULTS

Fungicide-Screening Trials

Fungicides tested alone did not control bean root rot (Table 1). Beans treated with Pittsburgh C-272, chloropicrin, Orthocide 75, and Phytoactin had lower root-rot ratings than the

Table 1. Effect of seven chemicals at three concentrations on severity of bean root rot[a].

Chemical	Rate or concentration per pot	Average disease ratings[b]
Griseofulvin-I	1000 ppm	1.6
	100 ppm	1.8
	20 ppm	1.3
Oligomycin	2000 ppm	.8
	500 ppm	1.1
	50 ppm	1.2
Chloropicrin	5.0 ml	1.0
	1.0 ml	.6
	0.5 ml	.4
Orthocide 75	1000 mg	.7
	300 mg	.9
	60 mg	1.6
Pittsburgh C-272	2000 ppm	.5
	500 ppm	.8
	50 ppm	1.0
Phytostreptin	1000 ppm	1.3
	100 ppm	1.7
	20 ppm	1.1
Phytoactin	1000 ppm	.9
	100 ppm	1.2
	20 ppm	1.4
Sterile check		.7
Inoculated check		1.9

NOTE: In the analysis of variance, treatments were not significantly different at the 5 percent level.

[a] Chemicals were applied to the soil in 100 ml of water per pot.

[b] Ratings based on a 0 to 4 scale. (Fig. 1b)

diseased checks; however, the analysis of variance utilizing the "F" test showed no significant root-rot differences between fungicidal treatments and inoculated checks. Griseofulvin-I, Oligomycin, and Phytostreptin showed no indication of control. Factors which might have resulted in non-significance of these treatments were large variation between replications and the relatively low disease rating of 1.9 of the diseased check when rated after 6 weeks of growth. This did not allow enough disease range on a scale of four for good disease rating differences.

Gibberellin-Fungicide Screening Trials

Some gibberellin-fungicide treatments, when compared with the inoculated check, significantly reduced bean root rot (Table 2). The treatments receiving 5 ml of urea-formaldehyde

Table 2. Effect of gibberellin with five fungicides on severity of bean root rot.

Chemical and rate of application	Gibberellin ppm	Gibberellin Type of application	Average disease ratings[a]	Variation from inoculated check
Urea-formaldehyde	1	Sprayed on	1.0	-1.2*
5 ml	5	primary leaves	0.2	-2.0**
Vapam-4S	1	Sprayed on	0.9	-1.3*
1 ml	5	primary leaves	0.4	-1.8**
Urea-formaldehyde	50	In talc	2.5	0.3
5 ml	5	seed coat	2.7	0.5
Vapam-4S	50	In talc	0.7	-1.5**
1 ml	5	seed coat	0.6	-1.6**
Orthocide 75	0	In talc	2.1	-0.1
45 mg per	5	seed coat	2.3	0.1
30 seeds	50		1.1	-1.1*
Pittsburgh C-272	0	In talc	2.9	0.7
.5 mg in 4 gm	5	seed coat	2.7	0.5
talc per 30 seeds	50		2.6	0.4
Oligomycin	0	In talc	3.1	0.9
.5 mg in 4 gm	5	seed coat	2.5	0.3
talc per 30 seeds	50		3.1	0.9
Sterile check			0.9	-1.3*
Inoculated check			2.2	
L.S.D. .05				1.0
L.S.D. .01				1.4

* Indicates significant difference at 5 percent level.
** Indicates significant difference at 1 percent level.
- Indicates less root rot infection than inoculated check.
[a] Ratings based on a 0 to 4 scale.

and 1 ml of Vapam-4S applied as a drench with 5 ppm gibberellin, sprayed on the plants at the primary leaf stage of growth, caused highly significant root-rot control. The same two chemical treatments with 1 ppm gibberellin resulted in control that was significant at the 5 percent level. One ml of Vapam-4S applied as a drench plus 5 and 50 ppm gibberellin in a talc seed coating also produced highly significant control of the disease.

Orthocide 75 at the rate of 45 mg per 30 seeds with 50 ppm gibberellin, both incorporated into a talc seed coating, significantly reduced the incidence of root rot.

Generally, the higher gibberellin-spray concentrations slightly increased the amount of

pod set, foliage growth, vining, and disease reduction as compared with plants sprayed with lower concentrations or seeds coated with this chemical. Maturity was hastened approximately 10 days by the higher concentrations of gibberellin and approximately 7 days by the lower concentrations. The greatest bean growth was induced by foliar applications, particularly when higher concentrations were used. Beans sprayed with 50 and 500 ppm of gibberellin showed nutrient deficiency symptoms in the older leaves after 6 weeks of growth.

Plants sprayed with gibberellin at 5, 50, and 500 ppm with no fungicidal treatment showed slightly higher root-rot indexes than did the inoculated check.

When the gibberellin-fungicide screening trials were set up the second time, the 50 ppm and 500 ppm foliar applications of gibberellin were not used because of excessive growth stimulation noted in the first test. The plants treated with 1 and 5 ppm of gibberellin were only mildly stimulated.

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WYOMING AGRICULTURAL EXPERIMENT STATION, LARAMIE

EFFECT OF CERTAIN CROP RESIDUES ON BEAN ROOT-ROT PATHOGENS[1]

Charles R. Maier[2]

Summary

Residues of cotton, soybean, sorghum, corn, sesame, lettuce, alfalfa, sesbania, barley, tomato, and sudan were tested for their effects on the relative populations of bean root-rot fungi, Fusarium solani f. phaseoli, Rhizoctonia solani, and other Fusarium spp., and Thielaviopsis basicola. Root-rot severity on pinto beans, and the frequency of occurrence of the fungi on isolation plates were employed as criteria for estimating relative populations. When mixed inoculum was used, finely-ground residues resulted in less severe root rot than did coarsely chopped residues, and mature or dry residues resulted in less severe root rot than did green residues. Root-rot severity with Fusarium as inoculum, was increased by alfalfa, sesbania, and tomato; with Rhizoctonia, by lettuce and tomato; with Thielaviopsis, by all residues except sorghum, soybean, barley, and sudan; and with mixed inoculum, by alfalfa, sesbania, and lettuce. Fusarium root rot severity was reduced by barley, sorghum, and corn; Rhizoctonia root rot by soybean, sorghum, sesame, alfalfa, and barley; Thielaviopsis by none; and root rot due to mixed inoculum by soybean, barley, sorghum, and sudan.

Root rot of pinto beans is caused by a pathogenic complex composed of Fusarium solani f. phaseoli, and other Fusarium spp., Rhizoctonia solani, and Thielaviopsis basicola. The relative importance of these organisms in disease incidence is dependent upon a number of factors, including the type of organic matter present in the soil, the type and abundance of associated soil fungi, and soil temperature and soil moisture levels.

In preliminary studies, Wiedman (4) found that Fusarium was isolated more frequently from diseased beans in New Mexico than were the other pathogens. In greenhouse studies with pinto bean root-rot, he determined that percentage of infection and disease severity were valid criteria for determining the effects of crop residues on the relative abundance of the bean root-rot fungi.

Fusarium and Rhizoctonia species are widely distributed in agricultural soils, and persist in the presence of suitable organic substrate, building up high populations on favorable host plants (1). The incorporation into the soil of residues in a crop rotation program may result in either an increase or a reduction in the incidence and severity of root rot of the following crop (3). In testing the effects of tomato, cotton, alfalfa, barley, and bean residues on bean root rot, Wiedman (4) reported that all residues increased the severity of Rhizoctonia root rot, barley reduced the severity of Fusarium root rot, and none affected the severity of Thielaviopsis root rot.

The present investigations were conducted to determine the effects of certain crops residues, representing New Mexico rotation crops on the relative populations of bean root-rot pathogens, and on the severity of root rot.

METHODS AND RESULTS

Soil from bean fields was sterilized with methyl bromide, placed in 6-inch clay pots, and residues incorporated at the rate of 1 percent on a dry weight basis. An artificial microflora consisting of 10 soil fungi recovered in greatest number was added to each pot and the pots watered daily for 4 days prior to inoculation or planting.

An experiment to determine the effects of crop residues as influenced by particle size and

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stage of growth on the relative populations of the pathogens was conducted. The residues incorporated were: barley straw, ground fine; barley straw, chopped; green barley, ground fine; green barley, chopped; alfalfa hay, ground fine; alfalfa hay, chopped; green alfalfa, ground fine; green alfalfa, chopped; and a no-residue control. Pinto beans were root-dip inoculated in both mixed inoculum and no inoculum, transplanted in the pots, and grown for 4 weeks. The root-rot severity was then recorded as the plants were pulled, and the beans replanted. Root-rot severity was again recorded after 4 weeks. These disease severity ratings are given in Table 1. Root-rot severity was less when residues were ground fine or when mature residues were used than when residues were chopped or green material was added.

Table 1. Effect of crop residues as influenced by particle size and stage of growth on the severity of root rot of pinto beans transplanted after a root-dip inoculation in mixed inoculum, and on beans grown from seed in infested soil.

Residue	Growth stage	Size of particle	Root-rot severity, rating 0-4[a]			
			Transplanted beans		Grown from seed	
			Mixed inoculum	Check	Mixed	Check
Barley	green	fine	2.4	0.4	2.6	0.5
Barley	green	coarse	2.8	0.6	3.0	0.6
Barley	mature	fine	2.0	0.4	2.2	0.4
Barley	mature	coarse	2.5	0.8	2.6	0.7
Alfalfa	green	fine	3.2	0.8	3.2	0.9
Alfalfa	green	coarse	3.6	1.0	3.6	1.0
Alfalfa	mature	fine	2.6	0.6	2.8	0.7
Alfalfa	mature	coarse	3.0	0.8	3.0	0.9
Check (no residue)			2.8	0.4	2.9	0.5
L. S. D., 5% level			0.55	0.37	0.41	0.33

[a] Mean of four replications of four pots (16 plants) each.

In experiments employing bean root-rot severity as a criterion for estimating populations of the pathogens as influenced by certain residues, soil was prepared as above. Dried and finely-ground residues of cotton (gin trash), soybean, sorghum, corn, sesame, lettuce, alfalfa, sesbania, barley, sudan, and tomato were incorporated, and an artificial microflora then added. The test plants were grown in sand flats until they had reached the two-leaf stage. Beans were root-dip inoculated in a culture suspension inoculum of Fusarium, Rhizoctonia, and Thielaviopsis alone and in combination, and then transplanted into the prepared soil, five plants per pot. Control series were prepared with no residue and no inoculum.

After 4 weeks in the greenhouse in a temperature range of 45° to 85° F, the beans were pulled and root-rot severity rated. Isolations were made from infected plants from each residue, and dilutions of soil from each residue prepared. The soil in each pot was then stirred, replanted to pinto bean seed, and watered. These seedling beans were rated for root-rot severity after 4 weeks, and the experiment discontinued.

The severity scale employed for bean root rot was as follows: 0 - no infection; 1 - slight hypocotyl or primary root discoloration; 2 - moderate discoloration with slight rot; 3 - moderate rotting of primary root and hypocotyl; and 4 - severe rotting to death of plants. The severity of root rot on the transplanted, root-dip inoculated beans and on beans grown from seed in infested soil, in both cases after 4 weeks, is given in Table 2. Disease severity ratings recorded are compared with the severity in no-residue checks.

The effect of crop residues on the severity of root rot, and thus on the populations of the pathogens, varied widely with the inoculum employed. Alfalfa increased the severity of Fusarium and Thielaviopsis root rot, but decreased that of Rhizoctonia root rot. It increased the severity of root rot produced by a mixed inoculum.

From the standpoint of the inocula employed, when Fusarium was used alone, sesbania, alfalfa, and tomato increased root-rot severity; root-rot severity was reduced by sorghum, soybean, corn, and barley, and not affected by the rest of the residues. Rhizoctonia root rot was increased in its severity by lettuce and tomato, decreased by soybean, sorghum, sesame, alfalfa, and barley, and was not affected by cotton, sudan, sesbania, and corn. All residues except

Table 2. Severity of root rot of pinto beans, as influenced by crop residue and inoculum, on transplanted, root-dip inoculated pinto beans and on beans grown from seed in infected soil.

Residue	Root-rot severity, mean of four reps (based on 0-4 scale)									
	Transplanted, inoculated beans					Beans grown from seed				
	R	F	T	Mixed	None	R	F	T	Mix	None
Cotton	2.4	2.8	2.3	2.6	0.4	2.6	3.0	2.4	2.8	0.4
Sorghum	1.8	1.6	2.2	2.3	0.6	2.0	2.4	2.2	2.2	0.5
Soybean	1.2	1.4	2.0	2.0	0.2	1.7	2.0	2.2	2.0	0.5
Corn	2.1	2.0	2.6	2.6	0.5	2.5	2.4	2.8	2.8	0.6
Sesame	2.0	2.4	2.8	2.5	0.6	2.2	3.0	3.0	3.0	0.8
Lettuce	2.8	2.7	3.0	3.2	0.8	3.2	2.9	3.2	3.4	0.9
Alfalfa	2.0	3.2	3.0	3.4	0.6	2.3	3.6	3.6	3.6	1.0
Sesbania	2.3	3.0	2.8	2.8	0.5	2.6	3.6	3.2	3.5	0.8
Barley	1.6	2.1	2.0	2.2	0.2	2.0	2.2	2.3	2.4	0.4
Sudan	2.2	2.3	2.8	2.2	0.5	2.7	3.0	3.0	2.8	0.5
Tomato	2.9	3.1	2.7	2.8	1.1	3.3	4.0	3.0	3.2	1.2
Check (no residue)	2.4	2.6	2.2	2.8	0.4	2.8	3.2	2.4	3.0	0.5
L.S.D., 5% level					0.37					0.49

cotton, soybean, sorghum, and barley increased the severity of Thielaviopsis root rot, and these residues had no effect. When a mixed inoculum containing all three pathogens was employed, root-rot severity was increased by alfalfa, sesbania, and lettuce, was not affected by cotton, corn, sesame, and tomato, and was reduced by sorghum, soybean, barley, and sudan.

Infected plants were washed thoroughly in running tap water, blotted dry, and hypocotyl and primary root portions cut into 1/2-inch pieces. These were surface sterilized in 2.5 percent calcium hypochlorite and plated on potato-carrot-dextrose agar. After 3 days at 26° C, fungi growing from the plant tissues were transferred to fresh PCDA plates, grown for 3 to 5 days, then identified. Soil dilutions were prepared in distilled water, and plates poured at $1:10^6$ dilution. The dilution plates were incubated for 3 days at 26° C, separate cultures transferred, grown 3 to 5 days, transferred a second time, and identified after 3 to 5 days. Some cultures had to be transferred repeatedly to obtain pure cultures. The frequency of occurrence on isolation plates of the bean root-rot fungi resulting from each residue and originating from mixed inoculum is presented in Table 3.

Table 3. Frequency of occurrence of bean root-rot pathogens and other fungi isolated from infected plant roots and hypocotyl, and from soil dilutions of infested, amended soil.

Residue	Number of times recovered on isolation plates[a]									
	Infected plants					Soil dilution				
	R	F	T	Other	Total	R	F	T	Other	Total
Cotton	3	10	0	7	20	5	8	1	12	26
Sorghum	4	7	1	6	18	3	5	0	9	17
Soybean	1	5	0	6	12	2	4	2	10	18
Corn	4	10	3	10	27	9	8	3	12	32
Sesame	6	14	3	8	31	8	7	4	12	31
Lettuce	16	22	7	5	50	17	14	6	8	45
Alfalfa	6	24	6	3	39	7	18	5	15	45
Sesbania	5	23	3	6	37	6 [9]	16	2	12	39
Barley	0	6	3	9	18	3	3	3	12	21
Sudan	3	11	2	5	21	5	7	0	14	26
Tomato	14	24	5	3	46	16	14	3	11	44
Check	12	10	1	7	30	13	8	1	13	35
Total	74	166	34	75	349	97	112	30	140	379

[a] From each residue, mixed inoculum, 12 plant tissues were plated, and six dilution plates poured at $1:10^6$ dilution.

The severity of root rot as affected by the incorporated crop residues and caused by the different pathogens was consistent with the frequency of isolation of the pathogens both from infected plant tissue and soil dilutions, which were used to estimate the relative populations of the pathogens. In root rot resulting from mixed inoculum, those residues which resulted in most severe disease supported the largest numbers of pathogens; that is, from soil amended by those residues in which root rot was most severe, fungi of the root-rot complex were recovered most frequently.

DISCUSSION

Over the range of inocula, reduction in disease severity and populations of pathogenic fungi resulted from soybean, barley, and sorghum; no effects were forthcoming from the addition of cotton, corn, sesame, and sudan; and increases were obtained by adding residues of lettuce, alfalfa, sesbania, and tomato. These trends are consistent with the author's observations concerning the severity of seedling diseases of cotton (2), which are caused by the same fungi, following various rotation crops.

The investigations of residue effects seek ultimately for rotation crops that will build up land fertility while reducing the hazard of injurious root rot to succeeding crops.

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PELLICULARIA ROLFSII ON MEXICAN AND TEXAS WATERMELONS

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Pellicularia rolfsii (Curzi) E. West[2] is seldom of importance on watermelons grown in the United States. However, during April, May and June 1959 the rot caused by this fungus resulted in considerable loss of Mexican watermelons in the Chicago market. The disease was observed in one carlot of Texas melons.

In eight cars of Mexican Peacock melons averaging approximately 1770 melons per car, the decay ranged from 9.6 to 30 percent. The greatest number of melons discarded from one car was 513 and the least 163. One car of Texas Charleston Gray watermelons on inspection had 4 percent of this decay, a loss of 42 melons.

Most of the melons had from 1 to 3 decay spots varying in size from 1/2 to 1 inch in diameter. Infections in many instances had occurred on the underside through mechanical injuries. A small, watery light-yellow discoloration surrounding the wound was often the first evidence of the disease. Discoloration and decay progressed rapidly (Fig. 1, A and B). In some

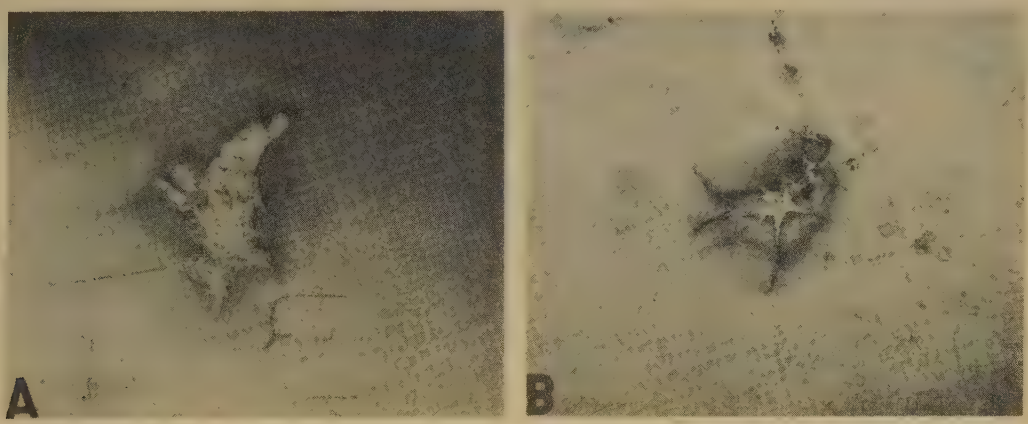

FIGURE 1. A -- Pellicularia rolfsii on Peacock watermelon from Mexico. B -- on Charleston Gray watermelon from Texas.

melons the rind was cracked open and the fine, silky, white mycelium was seen growing out in flat, fanlike radiations over the surfaces. Small, white, spherical sclerotia soon formed in the mycelium and within a few days had assumed a brown color.

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AN UNUSUAL OCCURRENCE OF MORELS IN CULTIVATED BEDS OF CYMBIDIUMS[1]

Kenneth F. Baker and O. A. Matkin

Man has long been interested in cultivating morels (Morchella spp.) for food because of their excellent flavor (8, 12). Attempts to do this in soil culture have involved the use of plants of Jerusalem artichoke, Helianthus tuberosus (9, 16), the non-fermented pulp of apples squeezed for cider (5, 9, 15), pulverized rotted pine wood or sawdust of poplar (2, 9), leaves, twigs, roots and wood of deciduous trees (6), or of old paper (9, 15). The method developed by the Baron d' Yvoire (18) in 1889 was recommended by Heim (9): A loose moist soil in which Jerusalem artichokes were growing was inoculated in May or June with fragments of fresh or dried morels. It was watered 4 to 5 times during the summer with dilute potassium nitrate. In the fall non-fermented apple pomace was placed around the artichoke plants to a depth of 1 cm, and covered 1 to 2 weeks later with dry leaves of hornbeam, chestnut, beech, oak, or ash, and twigs were placed on top. In April or May the twigs and leaves were carefully removed, and the area shaded with a cloth. A yield of 300 morels was obtained in an area of about 100 square feet. There is no indication that this method has been successfully used commercially.

Recently the mycelium of Morchella has been grown in submerged culture in nutrient solution (1, 3, 4, 7, 17) where it apparently developed the characteristic flavor, and formed small pellets suitable for use in soups.

The conidial stage, Costantinella spp., has been reported to develop on the surface of soil and in culture (5, 14, 15); sclerotia likewise are formed.

Because of this persistent interest in morel production, it was considered desirable to record an instance of their abundant development in California. For a 6-week period, starting in February 1956 there was a profuse development of morels in newly planted raised beds of cymbidiums in a nursery near the mouth of Zuma Canyon, 20 miles west of Santa Monica, California. This was during a fairly cool period, with a few very light rains. This phenomenon has not since recurred in either these same beds or any others, despite the fact that numerous ascocarps were allowed to mature to provide inoculum. This is the first instance known to the authors in which morels have developed copiously under conditions approximating those of potential commercial production.

The raised benches had been filled in July-September 1955 with ground bark of white fir (Abies concolor), a common growing medium used in cymbidium culture. The logs from which the bark was chipped were from an area burned over in 1955 and cut soon thereafter for lumber. The area was in the Sierra Nevada near Dinuba, California. The ground bark contained some wood fragments, due to the chipping method then used. Most other plantings have been in bark relatively free of wood fragments, and none have been in burned bark. At the time of morel development the bark was covered with fungus mycelium.

Dolomite lime was added at 10 pounds per cubic yard and the bark fumigated with gaseous methyl bromide prior to planting. When methyl bromide was applied at 2 pounds per 100 cubic feet the subsequent production of morels was heavier than when applied at 1 pound. No methyl bromide has subsequently been used for treating the ground bark.

The benches were planted after fumigation with cymbidium divisions and selections from plants previously grown in the same nursery. The benches were fertilized with liquid applications of ammonium nitrate (10 pounds/1000 gallons) and potassium chloride (2-4 pounds/1000 gallons) at 1 to 2 week intervals. The benches were mostly under Saran cloth netting, but some were in glasshouses.

The morel was apparently Morchella esculenta (L.) Pers. which, according to Dr. Lee Bonar, is widely distributed in the Sierra Nevada and the Coast Range of California. The source of inoculum is in doubt, but the following are possibilities:

1) Mycelium carried with the transplants. This would presume earlier inoculation and persistence of the fungus, but without sporulation until introduced into the burned and treated ground bark.

2) Spores carried with the bark from the burned area of the Sierra Nevada. Discomycetes (10) and morels (11, 13) occur commonly in soil of burned-over areas. McCubbin (13) reported that an area in Ontario burned over in October bore "immense numbers of morels"

[1] This report was prepared at the suggestion of Dr. E. B. Lambert, United States Department of Agriculture, Beltsville, Maryland, who read the manuscript and called attention to some of the references.

the following June and July. They could be found right up to within a few inches of the edge of the burned portion, but never beyond it." In the present example, if spores had been deposited on the bark and carried by it to the planting benches, it is probable that the methyl bromide fumigation there would have killed them. However, the spores may possibly be resistant to this gas.

3) Spores wind-borne from nearby ascocarps growing under native oaks and vegetation around the nursery. Morels normally appear in spring in California. Certainly spores would have been disseminated before the benches were available in July-September, and it is highly doubtful whether any would be disseminated long enough before the February appearance of the morels to permit necessary development of mycelium. Conidia may have been produced and perhaps have spread the fungus to the benches in the fall, but the unfavorable dry weather made this improbable.

It is suggested that anyone interested in the commercial growing of morels might well try a growing medium composed of slightly charred ground fir bark treated with methyl bromide prior to inoculation.

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A DISEASE OF POINSETTIA STOCK PLANTS CAUSED BY WATERLOGGED SOIL AND ITS CONTROL

C. M. Tompkins

Summary

The symptoms of stunt disease affecting container-grown poinsettia stock plants are described. Predisposing factors are heavy, poorly drained soils, no drainage outlets in the containers, excessive use of irrigation water, and lack of soil aeration. The disease may be controlled by modifying present cultural practices.

INTRODUCTION

Within the past decade, a destructive disease of container-grown poinsettia stock plants (Euphorbia pulcherrima), varieties Barbara Ecke Supreme, Indianapolis, Ecke White, and others, has been prevalent in glasshouses in the San Francisco Bay region. The annual loss ranged from 20 to 30 percent. Studies on etiology and control of the disease were conducted during the past 5 years, and the results are discussed in this paper.

SYMPTOMS OF THE DISEASE

The first visible symptoms of the disease appear several weeks after the container-grown poinsettia stock plants have been placed on glasshouse benches for forcing of vegetative growth at 75° to 80° F and at high humidity. New leaves, which are extremely small, slightly chlorotic, and somewhat pendant in comparison with normal growth at this stage of development, are borne on thin, under-sized stems arising from the main trunk. They fail to gain in size and become more chlorotic and less turgid with age. Eventually, and usually very suddenly, all the leaves wilt and hang vertically. A marked shortening of the internodes imparts a stunted appearance to diseased plants (Fig. 1). A soft, watery, odorless type of rot involves the root system, the smaller roots disintegrating before the larger ones. When the foliage wilts, only three to five stubs of the larger or main roots remain, which obviously are incapable of supplying the plant with water and nutrients.

In the final stages of the disease, the entire top turns brown and the plant dies. It can be removed from the soil with but little pressure. An occasional diseased plant may continue to live for some months in the stunted condition from which there is no recovery.

MATERIALS, METHODS, AND RESULTS

Approximately 100 diseased poinsettia stock plants, collected annually during the summer over a 5-year period, were tested in the laboratory and glasshouse. Poured plates of water, malt extract, and potato-dextrose agars on which root fragments had been placed remained sterile, indicating that no microorganism was involved. In the glasshouse, expressed juice from roots and leaves of the laboratory-tested plants was wiped on leaves of small healthy poinsettia, Turkish tobacco (Nicotiana tabacum) and N. glutinosa plants with the aid of carborundum[1]. Of 400 poinsettia, 200 Turkish tobacco and 200 N. glutinosa plants inoculated each year, none was infected.

In 1957 and 1958, experiments to ascertain the effect of certain cultural methods on this disease were conducted in the glasshouses of one local nursery. Each year 50 bare root poinsettia stock plants were placed in 5-gallon containers in each of eight lots, A to H. Lots A, B, E, and F had no drainage outlets. Lots C, D, G, and H had five square 3/4-inch outlets in the bottom and four on the side of each container and, in addition, were provided with a 1-inch layer of coarse gravel. The containers of Lots A to D were half-filled with heavy clay soil (the standard commercial practice), while those of Lots E to H were filled with a soil mixture consisting of three parts heavy loam and one part ratsnest[2]. At first, all lots were watered once

[1] Rawlins, T. E., and C. M. Tompkins. 1936. Studies on the effect of carborundum as an abrasive in plant virus inoculations. Phytopathology 26: 578-587.

[2] Ratsnest is a natural forest compost obtained usually in the redwood forest. It is used by many nurserymen in California in making up potting soil.

FIGURE 1. Poinsettia stock plants. At left, diseased plant showing many small leaves, shortened internodes. At right, healthy plant.

every 2 weeks in order to encourage root formation. Later, when the buds commenced to grow, the stock plants in Lots A, C, E, and G were given heavy, daily irrigation, while those in Lots B, D, F, and H received a relatively light application. All plants were syringed eight times daily in order to maintain a high humidity so essential for foliage development.

In general, the heaviest losses occurred in Lots A, B, E, and F which lacked drainage outlets. The losses from heavy irrigation in Lots A and E were slightly greater than those in Lots B and F which received lighter irrigation. A reduction in the number of diseased plants in Lots C and D occurred, but drainage and type of irrigation were of less importance than the heavy clay soil which became compacted and impervious to water movement. Apparently the irrigation water applied to the stock plants in Lots G and H drained well through the lighter and more porous soil mixture and finally through the gravel and outlets. No disease was observed in these lots. The poinsettia stock plants surviving each year in Lots A to F inclusive were much inferior in vigor and growth characteristics and produced few normal cuttings when compared with plants in Lots G and H. No fungi were recovered from diseased plants in Lots A to F after plating in the laboratory.

DISCUSSION

No two growers use the same cultural methods in forcing poinsettia stock plants under glass. In past years, the general practice has been to half-fill the containers with barely enough heavy clay soil to cover the roots. Usually the containers had no drainage outlets. Heavy irrigation commenced immediately after the stock plants were placed in containers and continued throughout the season. Soon the soil became waterlogged, aeration was lacking, and the roots quickly rotted, with the aid of secondary organisms.

The experimental studies indicate a method of control for this disease that is both effective and inexpensive. The essential features include the use of containers provided with ample drainage outlets, a layer of gravel, and a soil mixture that drains well. The soil, if virgin and clean, need not be sterilized by steam or chemicals, since fungus infection is not a factor. Moderate rather than heavy irrigation is preferable and facilitates aeration. If their health is maintained, poinsettia stock plants can be used for 2 or more years.

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LEAF ROT OF POINSETTIA CUTTINGS CAUSED BY RHIZOCTONIA SOLANI AND ITS CONTROL

C. M. Tompkins

Summary

A leaf-rot disease of unrooted and rooted poinsettia softwood cuttings, grown under glass in flats and small pots under excessively wet conditions, is caused by Rhizoctonia solani. The disease may be controlled by reducing the frequency of irrigation.

INTRODUCTION

During the summer and early autumn of 1958, a destructive leaf disease of poinsettia softwood cuttings (Euphorbia pulcherrima), variety Barbara Ecke Supreme, was observed in commercial glasshouses in the San Francisco Bay region. At one nursery where cuttings were rooting in flats of steam-sterilized soil (3 parts loam, 1 part peat, and 1 part sand) under automatic mist conditions (1 minute on and 1 minute off) at an average air temperature of 75° to 80° F, losses ranged from 50 to 100 percent in individual flats.

Elsewhere, the incidence of disease among cuttings grown singly in 2-inch porous clay pots of pure, sterilized river sand (grade No. 2) and syringed 8 or more times daily, was 10 to 20 percent.

The causal fungus, Rhizoctonia solani, has previously been reported as causing a stem and root disease of poinsettia in California[1] and is considered by the writer to be, with Pythium ultimum, the cause of serious losses each season of poinsettia plants being flowered under glass for the Christmas trade.

LEAF ROT SYMPTOMS

Leaf symptoms consist initially of small, irregularly-shaped, dark-brown, water-soaked lesions distributed at random on the lower leaves of the cuttings which are in contact with or near the surface of the soil mixture or sand. The adjoining healthy tissues are chlorotic, while the edge of the leaf curls upward (Fig. 1). As the discolored areas enlarge, there is some coalescence to form larger lesions, and the tissues become soft and flaccid. Within 2 to 3 days, the leaves are usually completely blackened and may become detached from the cutting. Occasionally the petioles are infected but not the main stem or roots. In succession, the disease spreads rapidly from the lower to the upper leaves. As a result of severe leaf infection, cuttings may die in less than 1 week.

MATERIALS AND METHODS

Small fragments of infected poinsettia leaves, previously disinfected and washed, were planted on poured plates of potato-dextrose agar. Colonies of Rhizoctonia solani developed in 2 days and pure cultures were established by hyphal-tip transfers. They were designated as isolates A and B, respectively.

INOCULATION EXPERIMENTS

Pathogenicity tests were conducted in a glasshouse at 75° to 80° F. Blocks of agar inoculum of each isolate were placed separately on the upper surface of each of three leaves of six healthy poinsettia plants and covered with moist absorbent cotton. Six control plants were treated with sterile agar blocks. After thorough watering, all plants were covered with bell jars to provide high humidity.

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[1] Tompkins, C. M., and John T. Middleton. 1950. Etiology and control of poinsettia root and stem rot caused by Pythium spp. and Rhizoctonia solani. Hilgardia 20: 171-178.

FIGURE 1. Naturally infected poinsettia leaves showing typical irregular-shaped, dark-brown, water-soaked lesions, chlorotic areas adjoining, and upward curling along the edge. The causal fungus -- Rhizoctonia solani.

RESULTS

Typical lesions developed on leaves inoculated with isolates A or B within 2 to 3 days, while leaf rot was complete in 5 to 6 days. Rhizoctonia solani was reisolated from the artificially infected leaves and was identical with the original isolates. All reisolates were pathogenic. The control plants remained healthy.

CONTROL

This disease was practically eliminated (a) by reducing the mist period from 1 to 1/2 minute and increasing the no-mist period from 1 to 1-1/2 or 2 minutes and (b) by reducing the number of daily syringings by one-half. As a result of curtailing overhead irrigation, not only was the disease reduced, but apparently cuttings were far superior to those rooted under conditions favoring the disease.

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SEEDLING ROT OF CARNEGIEA GIGANTEA (ENGELM.) BRITT. & ROSE CAUSED BY FUSARIUM SPP.[1]

John A. Booth and Stanley M. Alcorn[2]

Abstract

A soft rot disease of saguaro cactus seedlings, characterized by a black, watery breakdown of cortical stem tissue is described. Advance of the disease through the vascular system into the roots has often been noted, but initial infection of the roots with subsequent upward spread of the disease into the stem tissues has been infrequently observed. Three pathogenic clones of Fusarium oxysporum and one of F. solani have been isolated. Inoculation studies indicate that the organisms primarily invade wounds. The four isolates were also found to be pathogenic on five other species of cacti.

INTRODUCTION

Research in Tucson, Arizona which utilizes large quantities of saguaro (Carnegiea gigantea (Engelm.) Britt. & Rose) seedlings has been delayed occasionally by losses due to infection by what has been determined to be clones of two species of Fusarium. A survey of literature revealed no previous published report of a disease of saguaro caused by Fusarium spp. Petrak (4), in 1931, reported a watery stem rot of cactus seedlings of various species representing five genera caused by a species of Fusarium, "possibly identical with F. blasticola Rostrup." A variety of F. oxysporum Schlecht. causing a stem rot of mature Cereus schottii Engelm. was reported in 1934 by McLaughlin (2). Pasinetti and Buzzati-Traverso (3) isolated two new species, F. cactacearum Pasin. & Buzz. and F. cacti maxonii Pasin. & Buzz., from Thelocactus nidulans (Quehl) Britt. & Rose and Cactus maxonii Rose, respectively. It is assumed that a disease of mature plants rather than of seedlings was studied. A lethal root disease of mature Opuntia ficus-indica (L.) Miller caused by F. oxysporum Schlecht. var. opuntiarum (Speg.) Pettinari was reported in 1951 by Pettinari (5). Preti (6), in 1935, described a collar and tap root rot of seedlings of Cephalocereus senilis (Haworth) Pfeiffer caused by a species of Fusarium closely resembling F. dianthi Prill. Carpenter (1) reported that progressive softening and eventual collapse of whole pads of mature Opuntia megacantha Salm-Dyck are caused by a variety of F. oxysporum.

The occurrence of a disease of saguaro seedlings caused by Fusarium spp. is reported here and gross symptoms are described. The results of inoculation studies and a brief investigation of host range within the Cactaceae are also given.

SYMPTOMS

The disease was primarily noted on crowded seedlings between 0.5 and 2.5 cm in height. It was characterized externally by a dark green to black water-soaked spot without an advancing chlorotic margin. Lesions were most frequently observed near the soil line or base of the stem and occasionally near the apex. Rupture of the epidermis revealed a black watery rot not at all unlike a bacterial soft-rot. After the disease progressed through the cortex to the vascular system light brown streaks developed acropetally and basipetally from the point of vascular contact. Within 48 hours after the first water-soaked spots were noted the entire stem of a naturally infected plant was usually reduced to a semi-liquid mass contained by a more or less intact epidermis. In such cases roots were also affected. In only a few cases was it noted that root infection initiated stem rot. Figure 1 shows external and internal symptoms of naturally infected seedlings.

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[1] Arizona Agricultural Experiment Station Technical Paper No. 536.

[2] Biological Aid and Plant Pathologist, respectively, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Tucson, Arizona.

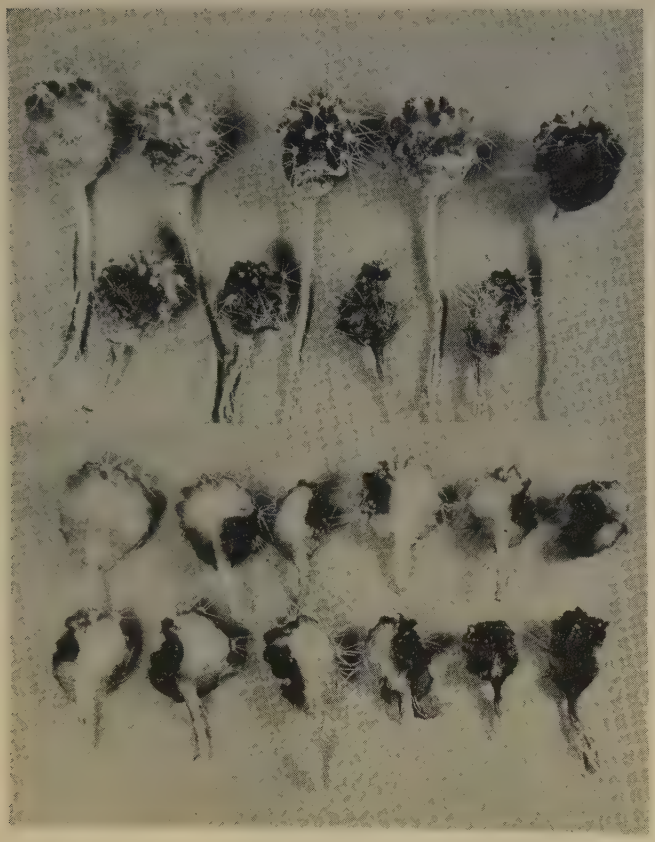

FIGURE 1. Saguaro seedlings showing varying degrees of natural infection by Fusarium spp. The upper group is made up of entire plants, while those below have been sectioned longitudinally to show internal injury. The upper left seedling in each group is apparently healthy.

CAUSAL ORGANISMS

Culture of diseased portions of 104 naturally infected saguaro seedlings resulted in the isolation of Fusarium spp. from 98. Bacterial growth was observed in seven cultures. The isolated bacteria proved to be non-pathogenic. Subsequent separation of the fungi by the single-spore method revealed four morphological growth types in 105 cultures. Three of the four types have tentatively been identified as clones of F. oxysporum (Schlecht.) emend. Snyd. & Hans. and the fourth is F. solani (Mart.) emend. Snyd. & Hans[3]. Further reference to the clones of F. oxysporum will be by the letter designations A, B and C.

INOCULATION STUDIES

Pathogenicity was confirmed by means of hypodermic inoculation of aqueous spore suspensions into the stems of healthy saguaro seedlings and re-isolation of the organisms after the production of typical symptoms. Plant pathogenic bacteria were at no time isolated from the inoculated seedlings. Twenty-two plants were inoculated with each isolate. Fusarium solani and clones A and B of F. oxysporum caused death of all seedlings within 2 or 3 days. Clone C, however, caused symptom manifestation in only 14 of the inoculated plants after 15 to 20 days, while the remaining 8 did not become infected.

Further studies of methods of inoculating healthy saguaro seedlings with F. solani included: 1) transplanting seedlings into chloropicrin-sterilized soil[4] infested with heavy spore suspensions; 2) transplanting seedlings whose roots had been dipped into heavy spore suspensions; and 3) and 4) spraying seedlings with wounded and intact epidermis with heavy suspensions of the fungi. The tests were divided into two groups, one of which received water once a week while the other was watered three times each week. The first test was replicated eight times in each of the groups and tests 2, 3, and 4 were replicated six times per group. Each replica-

[3] The writers are indebted to Dr. W. C. Snyder, Professor of Plant Pathology, University of California, Berkeley, California, for examination and identification of the cultures.

[4] A 4:2:1 mixture of Red Mesa loam, sand and manure allowed to air for 6 weeks prior to use.

tion consisted of three plants. Table 1 summarizes the results of these tests.

Table 1. Ratios of diseased plants to total numbers of saguaro seedlings inoculated with Fusarium solani.

Method of inoculation	Plants watered once weekly: Inoculated	Plants watered once weekly: Check	Plants watered 3 times weekly: Inoculated	Plants watered 3 times weekly: Check
Spraying spore suspension on:				
Wounded epidermis	4/18[a]	0/9	4/18	0/9
Unwounded epidermis	2/18	0/9	1/18	0/9
Dipping roots into spore suspension	1/18	0/9	0/18	0/9
Transplanting seedlings into infested soil	0/24[b]	0/9	3/24	0/9

a Six replications, three plants per replication.
b Eight replications, three plants per replication.

The susceptibility to F. solani and clones A, B and C of F. oxysporum of established seedlings with wounded roots was also investigated. Soil was scraped from the upper portion of the main root and a wound approximately 2 x 1 mm was made just into the cortical tissue. Five ml of a heavy spore suspension was applied to the wound and the soil was then replaced next to the root. Each series consisted of 10 inoculated plants. Six plants, comparably treated but not inoculated, were used as checks. All plants were watered two or three times weekly. After 20 days all F. solani inoculated plants were diseased, while 9, 10 and 7 of the plants respectively inoculated with clones A, B and C of the F. oxysporum became diseased. All check plants remained healthy.

The organism used in each series of inoculations was recovered in every case of apparent disease by culturing portions of the affected plants.

SUSCEPT-RANGE STUDIES

An attempt was made to determine the pathogenicity of the four Fusarium isolates to other representatives of the Cactaceae. Mature plants of prickly pear[5], Opuntia engelmanii Salm-Dyck, two species of cholla[6], O. fulgida Engelm. and O. versicolor Engelm., as well as seedlings of the organ pipe cactus, Lemaireocereus thurberi (Engelm.) Britt. & Rose., and the barrel cactus, Ferocactus wislizenii (Engelm.) Britt. & Rose, were used. Three hypodermic inoculations per isolate were made in each of the five species. Each isolate was inoculated into three separate pads or segments of the branched Opuntia spp. Separate seedlings were used for all inoculations of L. thurberi and F. wislizenii. Table 2 gives the ratios of disease occurrence to numbers of inoculations of each test species.

In only one case did a pad of O. engelmanii become diseased. The other inoculated pads did not develop symptoms beyond the area of inoculation. The diseased pad first showed, at the inoculation site, a dark-green water-soaked spot which became tan to brown with a slightly chlorotic advancing margin. Abscission before more than half of the pad was rotted prevented infection of the adjacent pad. Complete collapse of the abscised pad was noted 18 days after inoculation. Prior to desiccation in the final stages, the internal tissues showed a moist, brown to black, pulp-like condition unlike the watery breakdown of similarly affected saguaro seedlings.

O. fulgida and O. versicolor showed similar symptoms when infected by the four isolates. Here again abscission occurred prior to the advance of the organisms into adjoining segments. Symptoms included an initial browning with a slightly chlorotic advancing margin which gave rise to rapid dehydration and shriveling of the segment. Decomposed internal tissue was black and of a semi-dry, putty-like consistency. In all cases segments had become completely infected and had abscised within 7 days after inoculation.

Seedlings of L. thurberi showed symptoms similar to those shown by saguaro seedlings ex-

[5] Flat, pad-type, jointed stem.

[6] Cylindrical, cane-type, jointed stem.

Table 2. Ratios of disease occurrence to total numbers of inoculations of five cactus species with Fusarium solani and three clones of F. oxysporum.

Test plant	F. solani	Fusarium oxysporum A	Fusarium oxysporum B	Fusarium oxysporum C	Check
Opuntia engelmanii[a]	1/3	0/3	0/3	0/3	0/4
Opuntia fulgida[a]	1/3	2/3	3/3	2/3	0/4
Opuntia versicolor[a]	2/3	3/3	1/3	1/3	0/4
Lemaireocereus thurberi[b]	3/3	3/3	3/3	3/3	0/4
Ferocactus wislizenii[b]	3/3	3/3	3/3	3/3	0/4

[a] Three inoculations were made per plant in separate pads or segments.

[b] Single plants were used for each inoculation.

cept that the breakdown of internal tissue was less watery. Collapse of the seedlings usually occurred within 5 days after inoculation.

Seedlings of F. wislizenii did not show symptoms typical of the rot of saguaro seedlings but became chlorotic and shriveled. Internal tissues became dry, black and decomposed. This type of symptom development possibly could have been due to the reduced vigor and partially dehydrated state of the seedlings before inoculation.

Clone C of F. oxysporum did not attack the test plants as rapidly as did the other isolates.

Each isolate was reisolated from one representative diseased plant of each of the test species and was subsequently reinoculated into three saguaro seedlings. All 57 reinoculations gave positive results.

DISCUSSION

Inoculation studies made with F. solani show that the organism is pathogenic to saguaro seedlings, but that direct penetration does not readily occur. Natural infection is probably often effected when seedlings are propagated in such close proximity that the spines cause wounding of adjacent plants. Clones A and B of F. oxysporum also were highly pathogenic as shown by hypodermic inoculation. Excessive watering did not increase the incidence of disease.

The suscept-range studies indicate that the organisms are not specific on saguaro. Furthur work is needed to determine the relative pathogenicity of these clones to plants representing families other than Cactaceae.

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THE DECOMPOSITION OF CELLULOSE IN COTTON FIBER BY THE BLACK ASPERGILLI

Marion E. Simpson and Paul B. Marsh[1]

Abstract

The black Aspergilli grow commonly on both raw and processed cotton in many situations. Although Aspergillus niger has been believed to be a non-cellulose-decomposing organism, it is reported here that cellulose decomposition may be observed with this fungus if a small amount of glucose is added to the cellulose. In the experiments here described, the organism was incubated with strips of unbleached cotton fabric on a mineral salts-agar medium to which varying amounts of glucose were added; at suitable concentrations of glucose, distinct strength losses were produced in the strips. The degree of swelling of the fiber from the strips in concentrated alkali was found to increase during incubation. When several of the truly black Aspergilli closely related to A. niger van Tieghem were tested over a range of glucose concentrations, the changes in alkali-swelling for any isolate generally paralleled the strength losses. Both properties are considered to reflect cellulose decomposition, the alkali-swelling response being the more sensitive of the two criteria. Isolates of "purple-black" Aspergilli of the A. luchuensis series caused strength loss in the absence of added glucose, confirming previous reports in the literature.

BACKGROUND

Examination of hundreds of raw cotton samples in the writers' laboratory has disclosed the presence of black Aspergilli as one of the very commonest components of the microbial population of raw cotton produced in the western United States Cotton Belt. Aspergillus niger is known to be able to physically degrade undried cotton fiber which it attacks and to produce the common boll rot complex described by Shapovalov (9). However, evidence from the literature has suggested that this fungus is fundamentally incapable of attacking native cellulose as it exists in the boll after the period of opening (3, 4, 11, 12). The present paper involves a re-examination of the question.

Aspergillus niger TC-215-4247 has been widely used in the testing of mildew resistance of textiles and other manufactured articles and materials of construction. Because of numerous experiments in which it has failed to cause strength loss in cotton fabric (3, 4, 11, 12), the fungus has been generally regarded as incapable of decomposing cellulose. Klemme et al. (3) reported in 1945 that experiments with the organism (hereinafter referred to by the abbreviated strain designation "TC") resulted in no strength losses in cotton fabric. The fungus was incubated for 7 days on the fabric in the presence of mineral salts; under the same conditions many other fungi produced major strength losses. Various writers in the 1944-1948 period referred to the organism as a "superficial fungus," a "non-cellulose-decomposer," or a "superficial grower" (1, 2, 5).

In 1948, White et al. (11) reported on the cellulose-decomposing potentialities of 32 truly black isolates from the A. niger group. They found all these isolates unable to cause strength loss in cotton fabric. At the same time, however, one of the "purple-black" Aspergilli of the niger group, an isolate of A. luchuensis, did cause strength loss. In the same year, White, Siu, and Reese (12) published an extensive paper devoted to the black Aspergilli in relation to cellulosic substrata. On the basis of tests of 52 isolates, these authors concluded: "None of the truly black Aspergilli were found to be capable of cellulolytic action. Such activity was confined to the ochraceous A. niger mutant schiemenni and to the more or less purple-brown forms which

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comprise the A. luchuensis series. The results seem to warrant the general conclusion that, within the Aspergillus niger group, cellulolytic ability is absent in the A. niger series and the A. carbonarius series but is, in contrast, a fairly constant feature of the A. luchuensis series." Marsh et al. (4), in the following year, reported results on 13 isolates from the A. niger group which were in accord with the above-quoted conclusions in that two isolates from the A. luchuensis series were found to be active and all the truly black isolates exhibited little, if any, activity.

Siu (10) agreed that A. niger was a non-cellulose-decomposer when he stated in 1951: "When surface growth without attendant cellulose breakdown is being investigated, additional species, such as Aspergillus niger, should be used." A question about the validity of the generalization that no truly black Aspergillus can weaken cotton appeared in 1951 when Reese and Downing (7) reported that one of 13 truly black A. niger isolates was able to weaken cotton duck. In 1952, however, Reese and Levinson (8) reiterated their belief that the TC strain of A. niger cannot weaken cotton by stating: "It has always been considered non-cellulolytic... and must continue to be so considered, based on its inability to degrade cotton."

MATERIALS AND METHODS

The fungus isolates were from the U. S. Army Quartermaster Collection at Natick, Mass., ("QM"), the American Type Culture Collection in Washington, D. C. ("ATCC"), and USDA sources. "TC" refers to the Thom and Church collection. The TC isolate is stated by White, Siu, and Reese (12) to be typical Aspergillus niger van Tieghem sensu strictu.

The inoculum for the fabric tests was prepared by growing the fungi on a mineral salts-glucose-peptone-yeast extract-agar medium in 250-cc Erlenmeyer flasks. The mineral salt composition of the medium has been detailed previously (4). Glucose was used at 1.0 percent, peptone at 0.2 percent, yeast extract at 0.05 percent, and agar at 2.0 percent; 40 cc of this medium was used in each of the flask cultures, which were grown at 30° C until good sporulation had been attained. The incubations were carried out in 500-cc French-square culture bottles with metal caps, each containing 35 cc of an agar medium. The mineral salt composition of this medium was as in previous work (4), and the agar concentration 2.0 percent (Difco 140 B). Varying amounts of glucose were added to this basal medium.

The culture bottles, each containing the growth medium, were sterilized at 15 pounds' steam pressure for 15 minutes. The fabric strips, previously wet in water containing 0.025 percent of the wetting agent "Aerosol OT," were sterilized in a separate bottle. When the agar had hardened, the strips were placed individually into the culture bottles; sterility precautions were observed throughout. Sterile water was added to the fungus culture, the spores were shaken into suspension, and 1 cc of inoculum was pipetted onto each test strip. The inoculated sample bottles were then incubated at approximately 30° C for 2 weeks, at the end of which period the test strips were removed, washed in water, and dried under room conditions. They were conditioned at 70° F and 65 percent R. H. prior to breaking. The alkali-centrifuge test was carried out on ravellings from either side of the break on one of the broken test strips.

The fabric used was an unbleached 8-ounce cotton duck of a type designated as "Q duck." Breaking strength determinations were made by the 1-inch ravelled-strip method with a 3-inch span between the jaws of a pendulum-type tester. Each breaking strength figure is an average obtained from five replicate strips. The original breaking strength of the unincubated strips was 108 pounds. The alkali-centrifuge test was carried out as described previously (6). The term "alkali-centrifuge value" is used here exactly according to the previous definition (6, pp. 831-833) and is essentially a percent weight increase figure indicating the amount of alkali solution absorbed by the fibers.

EXPERIMENTAL RESULTS

The tests in which the TC isolate of A. niger had failed to bring about cellulose decomposition in earlier experimental work (3, 4, 11, 12) had involved incubation on fabric in the presence of mineral salts. In 1952 the TC isolate was retested with one added variable in the experimental conditions as compared with the prior tests (4), namely with the addition of 0.5 percent of glucose to the mineral salts agar medium. In the first such experiment, 10 replicate strips lost an average of 35 percent in breaking strength in 2 weeks of incubation. It was thought that this strength loss might possibly have been caused by a contaminant in the original culture. However, microscopic examination and plating out revealed no contaminants. Nevertheless, the results were checked by repeating the above experiment with a tube of the same

isolate obtained from the American Type Culture Collection. This time there was an even greater loss, 49 percent. As a still further check, a reisolation was made from a USDA tube of the TC isolate, and the entire experiment was repeated with this reisolate. Again there was a distinct strength loss, 44 percent.

The strength losses in the above experiments obviously were not related in any unique manner to the fabric used (Q duck), since tests with two other kinds of unbleached duck yielded strength losses of 46 percent and 47 percent, respectively. On the other hand, the strength losses clearly were related to the glucose, since incubations carried out on the same mineral salts-agar medium without the added glucose resulted in strength losses of less than 3 percent with each of the three different unbleached fabrics.

Experiments were now carried out to define more clearly the glucose-strength loss relationship, to investigate any changes in alkali-centrifuge values, and to determine the degree of generality of occurrence of the cellulose-decomposing ability among the truly black Aspergilli. Several of these forms were tested in the presence of a graded series of concentrations of glucose in the medium, Figures 1-3. Clearly, many of these "truly black" Aspergilli were

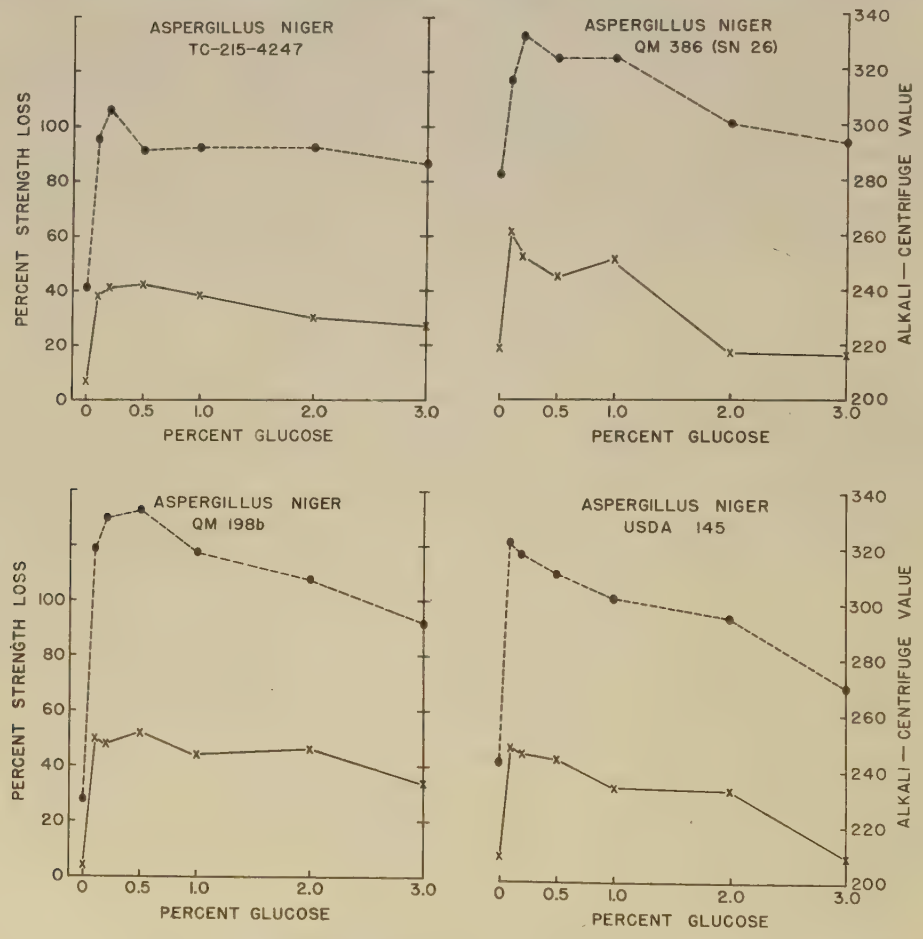

FIGURE 1. Effect of glucose content of the test medium on strength loss (——) and alkali-centrifuge value (---) of cotton duck measured after incubation in pure culture with four of the truly black Aspergilli. TC-215-4247 and SN 26 are standard fabric mildew resistance test fungi previously thought to be unable to weaken cotton fabric.

stimulated by the use of glucose in the medium to cause definite strength loss, an alkali-swelling increase in the fiber, or both. Results with A. luchuensis QM 874, one of the "purple-black" Aspergilli of the niger group, are presented for comparison in Figure 3. This fungus did not require added glucose to stimulate fabric breakdown. As the glucose concentration

was varied for any single fungus, the two properties showed a pronounced tendency to change in a parallel manner (Figs. 1-3). It was clear that the alkali-centrifuge value was the more sensitive property since it showed major changes in cases in which the strength losses were all less than 20 percent.

In order to determine whether members of the A. luchuensis series, a subgroup including the "purple-black" forms of the A. niger group, can decompose cellulose, 11 isolates from this series were tested. The incubations were carried out on mineral salts and on mineral salts plus 0.5 percent glucose. The results, Table 1, showed that 8 of the 11 isolates tested caused distinct losses at 0 percent glucose and 2 others caused strength losses at 0.5 percent glucose. These results confirm and extend the findings of previous papers (7, 12).

Table 1. Strength loss of gray duck caused by incubation for 2 weeks with members of the Aspergillus luchuensis series (subgroup of the A. niger group) in the presence of a mineral salts medium and of the same supplemented with 0.5 percent glucose.

Isolate	Percent strength loss with:	
	Mineral salts	Mineral salts plus 0.5 percent glucose
A. japonicus QM 155e	11	52
A. japonicus QM 332	8	41
A. japonicus QM 2018	60	44
A. japonicus QM 333	56	44
A. violaceo-fuscus QM 6649	63	55
A. luchuensis QM 21e	29	35
A. luchuensis QM 23b	44	31
A. luchuensis QM 102d	49	34
A. luchuensis QM 874	58	36
A. luchuensis QM 873	59	58
A. luchuensis QM 70c	6	9

DISCUSSION

Reese and Downing (7) have noted certain of the Aspergilli which are capable of causing strength loss in gray duck but not in bleached sheeting -- notably isolates of the A. luchuensis series and of the A. ustus and A. ochraceus groups. Without claiming any certain explanation of this phenomenon, they suggest that "highly bleached and desized cotton cloth may not support growth of an organism due to the absence of growth factors, whereas the same organism may grow well on the untreated fabric. This type of resistance may be overcome by adding the proper vitamins, minerals, etc." It may be noted that bleaching cotton removes not only minerals and vitamins but also glucose and that this last material may be important in bringing about the greater strength losses in gray duck as contrasted with those in bleached sheeting.

Acknowledgment

The authors wish to acknowledge their indebtedness to Dr. Hugh Gauch and Dr. Thomas Kerr for helpful comments during the progress of the work and to Miss Dorothy Fennell of the U. S. Quartermaster Research and Development Command, Natick, Massachusetts and Dr. Freeman Weiss, American Type Culture Collection, Washington, D. C. for kindly supplying cultures.

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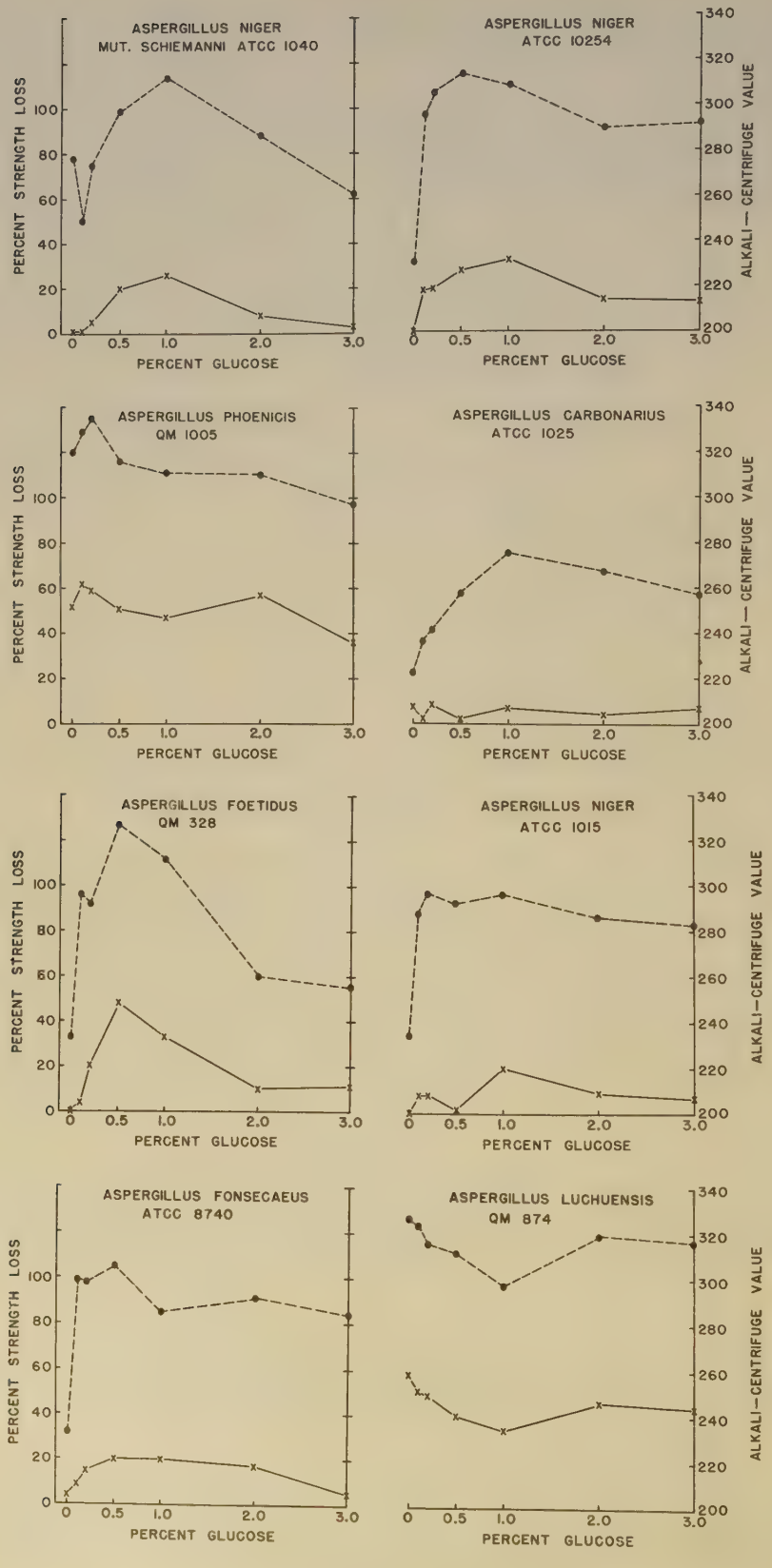

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Legends for Figures 2 and 3

FIGURE 2. Effect of glucose content of the test medium on strength loss and alkali-centrifuge value of cotton duck measured after incubation in pure culture with four additional truly black Aspergilli. Note in this figure and in Figures 1 and 3 the parallelism of the strength loss (——) and alkali-centrifuge curves (---) also that 10 of the 12 isolates tested caused over 20 percent strength loss and all 12 caused a major elevation of the alkali-centrifuge value over that of the original fabric (220).

FIGURE 3. Effect of glucose content of the test medium on strength loss and alkali-centrifuge value of cotton duck measured after incubation in pure culture with four additional black Aspergilli. All isolates in Figures 1-3 are truly black Aspergilli, with the exception of the A. luchuensis QM 874 shown in Figure 3; this is one of the "purple-black" Aspergilli of the niger group.

SURVEY OF COTTON SEEDLING DISEASE PREVALENCE AND SEVERITY OF LOSSES IN NEW MEXICO IN 1959[1]

Charles R. Maier[2]

Losses amounting to 2.05 percent of the total potential cotton crop, or over $1,350,000, were found to occur in a survey of major New Mexico cotton-growing areas. A field check was conducted in mid-May, when 187 fields were visited in 13 cotton-producing counties. Stand counts were taken, and percent loss of stand due to seedling diseases determined. The average stand over the State in mid-May was 3.3 plants per row-foot, with an average loss of 11.6 percent. These losses do not include seed rot or pre-emergence damping-off. The most severe stand reductions were suffered in Eddy and Dona Ana counties, where 14.2 and 13.0 percent, respectively, occurred. Least severe losses occurred in Lea and Curry counties, where losses averaged 8.5 and 9.6 percent, respectively.

Potential crop values were based on the 1959 planted acreages, calculated from the 1958 harvested acreages and yields, and assuming a similar yield for 1959. A second field check in early July of 128 fields yielded mean stands of 2.4 plants per foot, and revealed continuing losses from root rot in addition to those incurred in the seedling phase; these could only be estimated. Visits with over 100 farmers and county agents established that the ideal or desired satisfactory stand, mean for the State, would be 3.0 plants per foot. Loss estimates of seedling diseases were determined from this figure, from earlier disease loss percentages, and the prevalence of root rot on the later check. Data from the survey are given in Table 1. These figures do not include losses due to replanting or the costs of seed treatment and/or soil fungicides and their application.

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Table 1. Results of cotton seedling disease survey in 13 New Mexico counties in 1959.

Location county	No. of fields	Mean stand (10 feet) May 11-18	Mean stand (10 feet) July 7-10	Ideal stand	Mean % stand loss (May)	Root rot severity (July)	Acreage (1000) 1959[a]	Acreage (1000) 1958[b]	Yield, 1958[b] (bales)	Yield, 1958[b] (#/A)	Income, ($1000) 1958[c]	% value loss (arbit.)	% value loss (survey)	Total value[d] loss ($1000)
Chavez	27	35.8	25.9	31.0	10.4	1.4	35.7	32.1	56,100	900	12,350	1.5	1.5	206.2
Curry	17	33.3	23.5	30.0	9.6	1.3	1.5	1.3	950	350	300	2.0	2.0	6.8
DeBaca	7	29.4	--	--	10.7	--	0.3	0.2	345	750	125	3.0	--	8.0
Dona Ana	32	35.6	23.2	29.4	13.0	1.5	52.0	52.8	82,300	750	19,655	2.0	2.0	387.4
Eddy	48	37.8	23.4	32.2	14.2	1.5	32.0	28.0	54,100	960	11,500	2.5	3.0	276.0
Hildalgo	23	32.4	23.6	29.9	11.7	0.9	7.0	6.8	14,250	1005	3,800	3.0	2.0	77.8
Lea	30	40.2	24.9	31.0	8.5	1.3	28.0	25.3	35,600	675	6,800	1.0	2.0	102.0
Luna	38	31.3	24.0	28.6	12.4	1.6	16.0	14.3	28,500	960	5,600	3.0	2.0	122.6
Otero	17	31.2	24.0	29.3	13.2	1.3	1.6	1.4	2,600	890	420	3.0	2.0	10.8
Quay	18	33.6	23.6	28.5	12.2	0.9	2.7	2.2	2,520	550	410	3.0	2.0	9.9
Roosevelt	21	26.0	22.6	29.0	10.8	1.3	17.0	18.5	17,200	450	3,950	4.0	3.0	109.0
Sierra	18	30.3	23.4	32.3	12.6	1.4	2.9	2.5	4,060	780	690	4.0	3.0	24.0
Socorro	9	32.6	--	--	11.6	--	1.6	1.5	2,850	725	530	3.0	--	16.9
		Mean	Mean	Mean	Mean	Mean				Mean		Mean	Mean	
Totals														
New Mexico	305	33.0	23.8	30.1	11.6	1.3	198.3	186.9	301,375	749.6	66,130	2.3	2.05	1357.4

[a] Figures from county A.S.C. cotton allotment acreages.

[b] Data from U. S. D. A. Agricultural Marketing Service Report -- "New Mexico all Cotton -- Acreage, yield, and production, 1958."

[c] Figures estimates from county agents and gins in each county.

[d] Does not include costs of seed treatment or soil fungicides, or losses due to replanting costs.

STEMPHYLIUM SPECIES ON COMFREY

Samuel W. Braverman[1]

During the growing season of 1957-1958, a planting of comfrey, Symphytum peregrinum, P. I. 233329, at the Regional Plant Introduction Station, Geneva, New York was inspected and a leaf spot found severely attacking the lower leaves. Diseased material was collected and placed in Petri dish moist chambers for 48 hours. Conidia, typical of Stemphylium species, were found in abundance on the diseased leaf areas.

FIGURE 1. Symptoms of Stemphylium species on leaves of comfrey, Symphytum peregrinum.

Symptoms on the leaves consisted of irregular areas approximately 3-8 x 2-6 mm, brown and generally surrounded by a yellow border (Figure 1). Frequently lesions may coalesce leaving extensive areas of necrotic leaf lamina. Stems and petioles were not infected.

Conidia of the fungus from comfrey are similar to those of Stemphylium botryosum. Therefore four common legumes were inoculated with several isolates of Stemphylium from comfrey. The fungus is non-pathogenic to red clover, white clover, alfalfa and birdsfoot trefoil.

This is the first report of a Stemphylium species on comfrey.

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NEW RECORDS OF FIELD CROP DISEASES IN ISRAEL[1]

G. Minz and Z. Solel

1. Clover. The main clover variety grown in this country is Trifolium alexandrinum. In recent years new varieties have been introduced. Observations on the resistance of these varieties to diseases and pests revealed on red clover, T. pratense, a high degree of infestation by the root-knot nematode, Meloidogyne javanica (Treub, 1885) Chitwood, 1949. The local variety, T. alexandrinum, is only occasionally infested by root-knot nematodes, and then without a marked influence on growth response. Ring spot disease of leaves, caused by Stemphylium sarcinaeforme (Cav.) Wiltsh. (syn. Macrosporium sarcinaeforme Cav.), was also found on red clover.

Introduced shaftal clover, T. resupinatum, was found to be affected by leaf sooty blotch caused by the Polythrincium stage (P. trifolii Kunze) of Cymadothea trifolii Wolf (syn. Dothidella trifolii Bayl. Elliot & Stansf.). P. trifolii was recently isolated from T. alexandrinum and from wild T. resupinatum (1). The same cultivated variety had leaf lesions caused by Cercospora zebrina Passer.

2. Alfalfa, Medicago sativa, was infected by Pseudoplea trifolii (Rostr.) Petr., the fungus causing brown leaf spot.

3. Broad bean, Vicia faba, by Erysiphe polygoni DC., the fungus causing powdery mildew.

4. Fenugreek, Trigonella foenum-graecum, was found to be infected by two fungi causing leaf spots, namely Cercosporina sp. and Ascochyta sp. (1). It was heavily infested by a species of Meloidogyne, which differs from others hitherto described (5).

5. Sesame, Sesamum indicum. -- leaf spot, shot-hole and pod spots, all caused by Alternaria macrospora Zimm. This fungus frequently causes leaf spot on cotton, Gossypium hirsutum and G. barbadense (2).

6. Wheat. We found single plants of a CCC selection (Triticum vulgare) attacked by flag or leaf smut, caused by Urocystis tritici Koern. (syn. U. agropyri (Preuss) Schroet.). This fungus is known to occur in neighbouring countries (3, 6). Years ago it was intercepted on straw used for packing imported glassware (4).

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[1] Publication of the Agricultural Research Station, Rehovot-Beit Dagan. 1959 Series, No. 287 - E.

BOOK REVIEW

"MAATALOUDEN SANAKIRJA -- LANTBRUKETS ORDBOK -- LANDWIRTSCHAFTLICHES WÖRTERBUCH -- AGRICULTURAL DICTIONARY". Compiled under the auspices of the Scientific Agricultural Society of Finland, by Liisa Mali. Helsinki, Kustannusosakeyhtiö Otava. 1958.

This comprehensive four-language -- Finnish, Swedish, German, English -- dictionary of technical agricultural terms will be most useful to persons who wish to consult the literature published in any of these languages on any aspect of agricultural science or practices. The arrangement is very convenient. In the first part the Finnish words are defined in terms of their equivalents in Swedish, German, and English. Separate alphabetical indexes for each of the other languages, and another index of scientific names and terms such as medical or anatomical names, refer to column and line number in the Finnish list. Symbols designate the particular field to which a definition applies, for instance plant diseases. For ease of consultation the symbols are printed on two stiff paper bookmarks, as well as in the front of the book as usual. A brief list of units of measurement is included.

The production of such a dictionary as this one requires much more than routine compilation, as shown by this paragraph quoted from the introduction "To the user of the dictionary", page VIII:

"The preparation of a dictionary, which might be considered a tedious task, is indeed a heavy undertaking. On the other hand it is an interesting one if only on account of the difficulties it is perpetually presenting. A multi-lingual dictionary demands more than skillful translation on the part of the compilers; it involves not only the preparation of the material in the various languages but research work also. The scope of the concepts being prepared must be surveyed, defined, and if necessary made more accurate. The concepts must be studied within the sphere of each separate language concerned, and comparatively between one language and another."

The book is clearly printed on paper of excellent quality. Altogether it is a very attractive publication.

The price is not given. Apparently the book is available only from the publisher in Finland. -- JESSIE I. WOOD

BRIEF NOTES

PREDICTION OF OAT YELLOW DWARF EPIDEMIC

By John F. Schafer[1], Ralph M. Caldwell[1], W. B. Cartwright[2], and R. L. Gallun[2]

During the second week of May 1959 an outbreak of aphids was observed on spring oats at Lafayette, Indiana. The species present were identified as the greenbug (Toxoptera graminum (Rond.)), the English grain aphid (Macrosiphum granarium (Kby.)), and the apple grain aphid (Rhopalosiphum fitchii (Sand.)). The greenbug comprised approximately 75 percent of these populations. On the basis of the excessive numbers of aphids present, it was suspected that the yellow dwarf (red leaf) disease of oats, caused by the aphid-borne barley yellow dwarf virus, might in turn be more prevalent than in most years. Following this prediction, experimental oat plantings at Lafayette were sprayed with a systemic insecticide to reduce the aphid population and thus protect this research material against possible subsequent spread of the yellow dwarf virus.

The prediction of prevalent yellow dwarf disease and the precaution to protect the experimental oat plantings proved well founded, as the disease developed earlier, more widely, and more severely on unprotected oats than during any other year of at least the last 30. This 1-year observation suggests that prediction of possible outbreaks of oat yellow dwarf in Indiana could be based on the presence of excessive aphid populations in early May. Possible additional support for such a prediction is that in 1949, another year of yellow dwarf epidemic in Indiana and adjacent areas, a greenbug outbreak extended farther north than usual although no records are available for Indiana. The prediction of a possible yellow dwarf epidemic would be of economic importance in that seedsmen and other oat producers would have time to apply an insecticidal spray prior to widespread secondary transmission of the virus.

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LATE-FROST DAMAGE TO CORN IN SOUTHERN WISCONSIN[1]

By Paul E. Hoppe[2]

A sudden and severe occurrence of leaf necrosis in corn knee-high and taller in extreme southern Wisconsin, near Janesville (Rock County), was diagnosed on June 19 as frost damage.

A check with the U. S. Weather Bureau at Janesville indicated that the frost probably occurred the night of June 14, when a minimum temperature of 46° F was recorded at the Station. This agrees approximately with the time interval that might be expected between the occurrence of the frost and the time damage became generally apparent. On June 19 the County Agricultural Agent at Janesville was deluged with telephone calls from farmers inquiring about the cause of the "dying" corn.

While the area of frost damage appears to have been mainly in southern Rock County, reports have been received that some fields in northern Illinois also were affected. The injury was confined to corn in low-lying fields or to plants on the lower parts of sloping land. Damage to individual plants varied from slight to extensive. Burdock and other weeds along the edges of a field where damage was most severe also were frost-injured.

That losses in yield may be substantial in the affected areas goes without saying, although at this time accurate appraisals of ultimate damage are difficult to make. June 14 is believed to be the latest date on record for severe frost damage to growing corn in southern Wisconsin.

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